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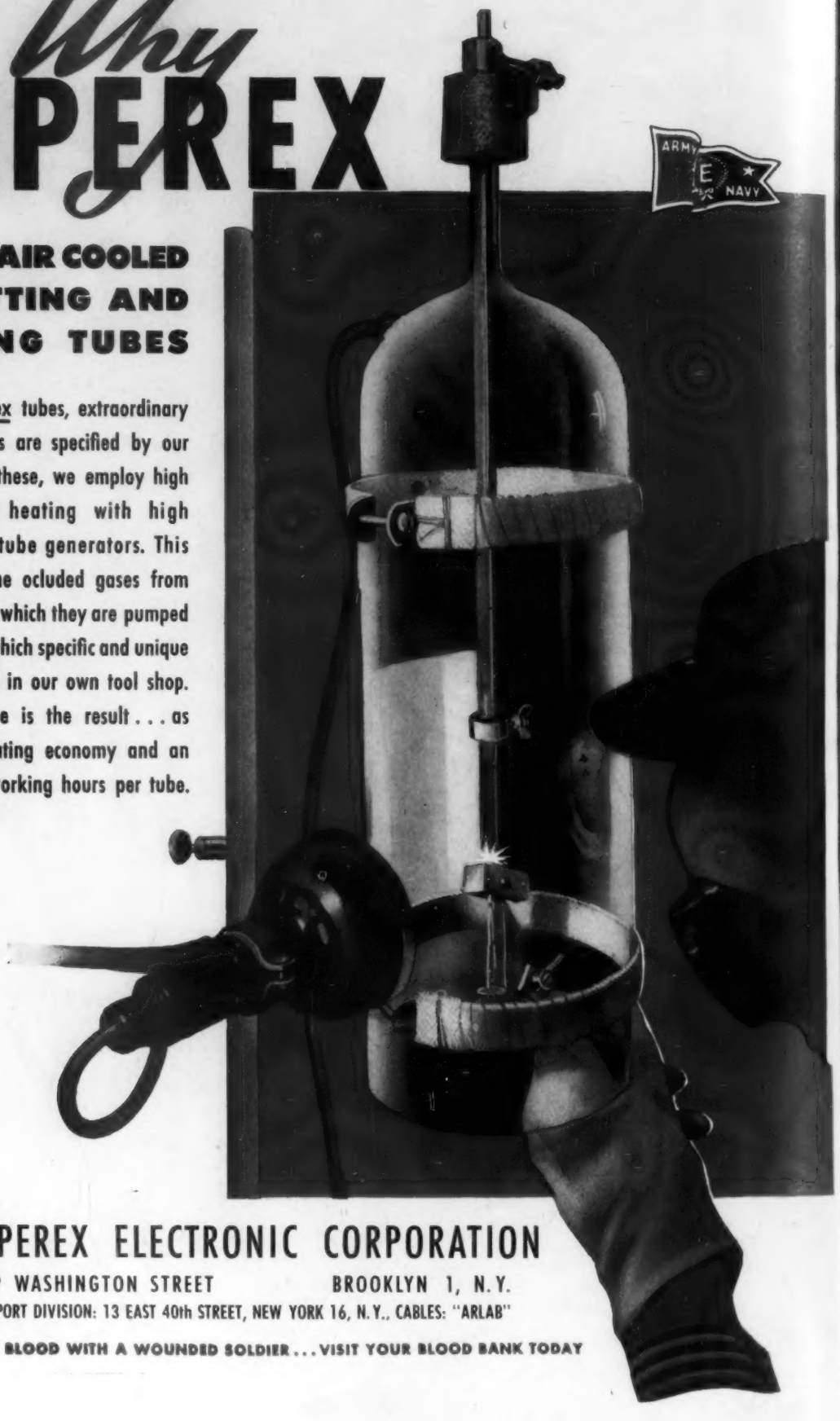

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KLYSTRON ..... Cover
Sperry glass-lathe worker manipulates 410-R tube in production. Colored pipes supply various needed gasses

ECHNICAL PLAN FOR POST-WAR TELEVISION 92
A review of RTPB-proposed frequency allocation and standards

ARMY AIRWAYS COMMUNICATIONS SYSTEM 98
Army Air Force affiliate facilitates military flying and points the way for post-war air travel

LECTRONIC COMMUNICATION FOR TRAINS, by William S. Halstead 102
Discussion of radio, rail-carrier and induction systems

YNCHRONIZED OSCILLATORS AS F-M RECEIVER LIMITERS, by C. S. Carnahan and Henry Kalmus .. 108
Theory and advantages of synchronized oscillators for use in f-m receivers

ARRIER COMMUNICATION TO CRANE CABS, by M. L. Snedeker 112
Special equipment provides flexible, centralized control in industrial plants

ISH TALK 115
Sounds made by fish are picked up by an underwater microphone for viewing with c-r oscilloscope

-VOLT OPERATION OF RECEIVING TUBES, by C. Hammond, E. Kohler and W. Lattin 116
Problems encountered when using aircraft battery as B-supply, with operating recommendations and performance data

RYSTAL TESTING TECHNIQUES, by L. A. Elbl 120
Daily production and acceptance test routine of a crystal finishing laboratory

FFICIENCY OF INDUCTION HEATING COILS, by George H. Brown 124
Mathematical analysis of heat-producing action, with graphs showing various factors affecting efficiency

OMMENTS ON HIGH FIDELITY, by O. B. Hanson 130
Technical; economic and human considerations in designing post-war high-fidelity audio systems

NTRODUCTION TO TRANSIENTS—PART I 132
Beginning of a serialized elementary treatment of non-sinusoidal and transient wave forms

NETWORKS AS COUPLED TANK CIRCUITS, by Frederic D. Schottland 140
Design procedure for matching r-f output stage of transmitter to antenna without an output transformer

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DEPARTMENTS

Crosstalk 91
Industrial Control 146
Tubes at Work 174
Electron Art 214
News of the Industry 276
New Products 344
New Books 400
Index to Advertisers 413

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THE NATIONAL DEBT—
and Your Postwar Job

Coming upon the heels of a ruinous ten-year depression, this war has once more made it clear to us that the strength of our country depends upon our ability and willingness to produce. Until the world conflict eclipsed the depression, we saw what failure to use our productive capacity can do—even to a country potentially as rich as ours.

The stark reality of war finally shocked us out of our economic lethargy. The necessity of supplying our Armed Forces with almost unlimited quantities of goods unleashed our inventive genius and revealed to us our real capacity to produce. It indicated what our standard of living might be if, in time of peace, we used our full productive capacity.

Today we are producing more than all the other nations combined, half again as much as in 1940. Today our production is insuring victory to our fighting men.

But what of the future?

Already our national debt has reached astronomical proportions, and it is going higher. The depression years' fear of insecurity that all but paralyzed our spirit of enterprise, our inventive genius, and our natural instinct for expansion, appears likely to return promptly if industrial activity again is curtailed for long because of unwise public policies.

This war is being fought to make men free. But our economy cannot be kept free through military conquest alone. There is another responsibility which we on the home front cannot avoid any more than we can build walls around our future. That is the problem created by our frightening public debt.

This is a two hundred billion dollar war. It affects the lives of every one of us. At the end of this war, the public debt of the United States will be at least ten times the twenty-five billion dollars that it was at the end of the first World War. It will be almost twice the present annual national income of the country. The interest charge alone will be about 4 per cent of the national income. If the burden were spread evenly, interest alone would take at least $80.00 of every worker's income per year, or approximately $1.60 out of each and every weekly pay check.

Some people fear that the heavy taxes required by the debt will keep the country poor by obstructing employment and limiting the output of goods.

Others believe that the size of the debt does not matter because we owe it to ourselves. They reason that if A is taxed $100 to pay $100 interest to B, A has $100 less to spend and B has $100 more, but both together have the same amount. They, therefore, hold that the demand for goods and the volume of employment remain unchanged.

Which view is correct?

Is our huge debt bound to be a crushing burden which limits employment and lowers the nation's standard of living, or will it simply redistribute income? May the public debt under certain conditions even be used to help increase employment and raise our living standards?

Most people, rich and poor alike, find it difficult to believe that the national debt "just doesn't matter". They know that the interest alone on this huge debt will be almost equal to the total amount of taxes ever raised before by the government for all purposes in any peacetime year. They find it difficult to follow the kind of reasoning that suggests increasing the already mammoth debt year by year in order to maintain full production and employment. They fail to see how this "debt raising" can go on indefinitely.

On the other hand, the records show that other nations have more than once successfully managed even greater debt burdens than will confront the United States after the present war. The interest on the British debt after the Napoleonic Wars was nearly 8 per cent of the national income, and after the first World War was over 7 per cent. But despite heavy taxes and some unfortunate mistakes in economic policy (such as restoring the prewar pound), per capita real income in Great Britain rose about 31 per cent between 1920 and 1929. In fact, it rose as rapidly as it did in the United States. The world depression was far less severe in Britain than it was in the United States; and, by 1936, when industrial production still was 6 per cent below 1929 in the United States, it was nearly 16 per cent above 1929 in Britain. Britain's heavy debt burden proved less of a handicap to her during the depression than our weak banking system did to us.

Whether the debt becomes a crushing burden or whether we use it to further our progress depends upon who holds the debt and how the money is raised to pay the interest.

Here are the important possibilities:

1. If the expenses of the government, including the interest on the debt, are met largely by heavy taxes upon business profits—i.e., by taxes upon job-giving—then they will reduce employment, output, and our standard of living, regardless of who holds the debt. Heavy taxes on profits prevent enterprise from expanding current operations or enlarging the capacity of its plants, unless the prospects for profit seem certain and the prospects for loss are slim. Hence the jobs that might be created to take advantage of long chances will not come into existence, and the country as a whole will be poorer.
2. If the expenses of the government are met largely by stiff surtaxes upon the incomes of persons who do a considerable amount of saving, and the debt is, in the main, owned by millions of small investors, then the net effect of the debt upon the volume of employment and output will be fairly neutral. The stiff surtaxes, while reducing the savings of the well-to-do, will cause them to avoid risky investments and to hold part of the savings of each year in the form of cash. This will limit the demand for goods and the volume of employment. But this effect will be partially offset if millions of small holders of the debt are led by their savings in government bonds to spend a larger part of their current income.
3. If the expenses of the government are met largely by sales taxes or other taxes on small incomes, and if the debt is held largely by the well-to-do or by business corporations, then the effect of the debt will be unfavorable to employment and production. The limitation to the spending power of the small-income group will reduce the volume of investment opportunities, and the transfer of income to the well-to-do will increase the volume of investment-seeking funds.
4. If the debt is widely distributed among millions of small holders, and the expenses of the government are met largely by taxes on individuals, if substantial exemptions from surtaxes are given for all income invested in new plant or equipment, and if there are liberal offsets for losses, then the debt will help increase employment and raise the standard of living. The millions of small holders will gain a sense of security from their accumulated savings and hence be encouraged to spend a larger portion of their current incomes. The stiff surtaxes will reduce the savings of the well-to-do; liberal exemptions for income put into new plant and equipment, and generous treatment of losses, will cause the well-to-do to invest their savings in job-giving enterprise rather than to hold them in idle cash.

But what is the situation today?

Today, non-banking corporations own nearly half of the Federal debt, commercial banks about one-fourth, and individuals less than one-fourth. Not more, and probably less, than one-tenth of the debt is held by persons earning less than $5,000—although these persons receive three-fourths of all income.

Today, about half of the revenues of the Federal government come largely from taxes which must be regarded as ***taxes upon the creation of new jobs.*** If these conditions continue, we may be sure that the debt will be a disastrous obstacle to a rising standard of living after the war.

What can be done to change this situation?

To begin with, vigorous steps should be taken to get much more of the debt into the hands of individuals, particularly of those in the small-income group. During the last three years, the incomes of individuals, after taxes, have exceeded the supply of consumer goods by $74.2 billion. In other words, individuals have been compelled, by the sheer scarcity of goods, to save over $74 billion. Of this amount, only $27.4 billion, or 37 cents out of every dollar, has gone into government bonds. Indeed, individuals have saved more in the form of cash and bank deposits than in the form of government bonds. The sale of war bonds to individuals was most disappointing in the recent drive. It was so disappointing, in fact, that I would favor a special drive ***for individuals only,*** to be scheduled before the next general drive. During 1944, when the supplies of civilian goods are severely restricted and when the fighting is at its climax, the Treasury will have its best opportunity to persuade individuals to buy more bonds. This opportunity should not be lost. An increase of at least twenty-five billion should be the goal for the next year. Every citizen should be made to understand that by buying war bonds now, he is not only helping to win the war; he is helping to make possible a more prosperous and stable America after the war.

The efforts to sell bonds to individuals should be vigorously continued throughout the shift from war production to civilian production. During this period, corporations which, up to now, have been the largest buyers of government bonds, will need all their depreciation allowances and undistributed profits to pay for new equipment, and to restore their own dealers' inventories. The government, however, will still have large bills to settle and will need to sell as many bonds as it can for some months after the end of hostilities. During this period, the demand for most types of goods is likely to exceed the immediate productive capacity of industry. Hence, the sale of bonds by the government will make for economic stability.

The huge expenses, including interest on the debt, which the government must meet after the war, require that the tax system be drastically reformed. Today, taxes fall most heavily upon those incomes which are the reward for increasing production and employment, because profits are taxed first as corporate profits, and taxed again as dividends to owners of the corporation. Surtaxes are so stiff and offsets for losses so meager that the well-to-do capitalists cannot afford to encourage and help promising young businessmen to start new enterprises.

A nation whose expenses are as large as those of the United States will be after the war must be sure that its tax system provides incentives, not penalties, for increasing production and employment.

Should the debt be repaid? Some people fear that any reduction of the debt would have a deflationary effect and cause unemployment. An opposite view was expressed by Mr. Morgenthau recently: "We have a big public debt that must be paid off, and the quicker we do that the better." Both of these views are extreme. Repayment of part of the debt during a period of depression would increase unemployment. Every period of high prosperity, however, would give the government an opportunity to pay off part of the debt without limiting employment. During these periods of prosperity, business corporations will sell government bonds in order to buy equipment; and many individuals will redeem war savings bonds in order to purchase houses, automobiles, and other goods. If the government budget runs a surplus during periods of high prosperity, and if this surplus is used to retire some of the bonds sold by corporations or redeemed by individuals, the country will be protected against a disorderly and speculative rise in prices. Thus, reduction of the debt can be made a device for stabilizing our economy.

There are two other reasons why reduction of the debt will be desirable.

In the first place, it will help prepare the country financially for a possible third World War. Determined as we are that this war shall be the last one, common sense tells us not to count on this. At any rate, we must be prepared for any eventuality.

In the second place, gradual reduction of the debt would stimulate employment by creating the expectation of lower taxes. It is not generally appreciated how much the willingness of individuals and business concerns to spend money is affected by the prospects of higher or lower taxes. One of the best ways to make individuals and enterprises spend more freely is to convince them that taxes will become a little lower, year by year.

Many people have difficulty in visualizing the day when there will be a substantial reduction in the burden of the national debt. And yet, if the country pursues wise economic policies, there is no reason why the debt burden should not be cut in half during the next generation.

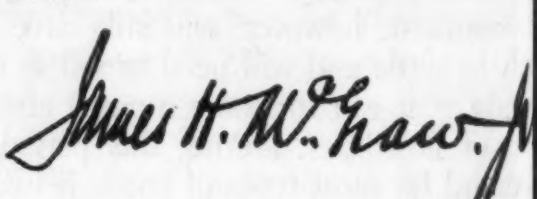
The days of technological progress and economic expansion are not over. They are, in fact, only well begun. During the Twenties, the national income in dollars of constant purchasing power increased by well over 50 per cent. Between 1929 and 1939, it increased by less than 6 per cent. Perhaps the rate of the Twenties cannot be maintained indefinitely; but scientific research and development work in industry are laying the foundation for very large advances in national income. Suppose that the national income increases 33 per cent in the first decade after fighting stops (say, hopefully, 1945), 25 per cent in the next decade, and thereafter at the rate of 20 per cent a decade. In 1955, the national income (at present prices) would be about $173 billion; in 1965, about $216 billion; and in 1975, about $257 billion. By 1970, the burden of the debt would be reduced by nearly half, even if not a cent of it were repaid!

A huge public debt is a test of the character, the common sense, the foresight, and the equally important technical and engineering skill of a nation. *It requires that tens of millions of small income earners be willing to become substantial holders of the debt. It requires that the nation be willing to tax itself heavily, but in ways which increase the attractiveness of job-giving or self-employment relative to job-holding; it requires that the nation be willing to pursue policies of expansion and to put a rising income for the nation ahead of the pleas of self-seeking groups in labor, agriculture, and industry.*

A huge debt may so draw out the hidden powers of a people that it makes the nation wealthier rather than poorer, stronger rather than weaker.

Up to now, Americans have not met the test of a big public debt too well. Individuals have saved more in cash than in government bonds, and the country has shown little interest in avoiding the kind of taxes that reduce the demand for labor. These shortcomings, I am sure, stem largely from the fact that the American people never have had the problems of debt and taxation honestly and adequately explained to them.

I have confidence in the American people. I believe that Americans have the intelligence to understand this problem of the public debt, the character to face their responsibility regarding it, and the common sense to accept the challenge and make the most of it.



President, McGraw-Hill Publishing Company, Inc.

CROSS TALK

▶**PRIDE** . . . At the close of the New York Philharmonic concert on June 25, the United States Rubber Company stated over the CBS network that "there could be no rubber industry without chemists." This was a very fine acknowledgment from one of America's large industrial concerns that its business was dependent upon its technicians. It is a fact, of course, but it is no more true of the rubber industry than it is true of the radio industry. Yet—has there ever been a member of the radio industry who had the grace to make a similar public statement?

For some reason the role played by radio engineers has never been played up; never glamorized; seldom acknowledged. In fact large elements of the radio receiver business have felt that its engineers were necessary evils, payroll names to be unloaded in bad times when company policies and company politics got in a turmoil.

Radio engineers today are in a different situation. Their work is properly assayed by the war agencies which make such good use of them; engineers are in great demand; they have a big share in big things. Their ego must have improved. It is difficult to estimate too highly, however, the betterment of the average radio man's morale if the radio companies suddenly realized the fact that "there could be no radio industry without engineers" and began to tell that fact to the public; began, in truth, to take some pride in their technicians.

▶**AMATEURS** . . . In spite of the fact that everyone admits the value of the radio amateur in time of peace or war, disquieting rumors get about that he is to be liquidated.

This seems highly undesirable from every standpoint. As he has demonstrated time and again, the amateur is an essential element of the radio industry, an essential part of our national life. This is not true, alone, because he pounds brass and can help out in time of distress; nor is it true because he builds radio apparatus and, therefore, is an engineer; nor is it true, alone, because he is a member of the amateur game where he has learned the value of a high *esprit de corps*. The amateur is all of these—he knows his equipment, he can build it and maintain it in operation; he has enough theory, and lots of practical experience and knowledge.

Within the past few months, the Editor of ELECTRONICS has had his hands full of a high-priority job for one of the armed services. Many men have been hired. It is only fair to state, right now, that the best men on his staff are those who have had amateur experience. This testimony is available anytime, anywhere that it may be useful in keeping the amateur in radio after the war.

▶**FUN** . . . Within the last year much has been made of the electronic method of flowing tin on tinplate. The plate is first coated with tin in an electroplating process; then by induction heating, the tin is flowed so that it goes into all the little crevasses of the material coated. Very nifty system. Now comes one Craig Walsh, ex-Associate Editor of ELECTRONICS, and states that he has a much simpler process. He simply boils the coated plate in Crisco!

OPA cracked down on the black market in radio sets in New York City recently. Seems the boys were buying up junk parts, old auto sets, components, etc., putting them together for a few dollars, selling the assembly for many dollars more than the ceiling price for sets of similar numbers of tubes etc., permitted. Sounds just like the good old pre-war days!

MD., DD., LLD . . . Mairzie-Doates, Dozy-Doates, Little-Lamsie-Divy.

Technical Plan For POST-WAR

The Television Panel of the Radio Technical Planning Board, in its latest report, suggests a vast new empire for television, including 26 commercial channels from 50 to 246 Mc, with relaying and experimental channels extending above 10,000 Mc

ON June 2, 1944, the Television Panel of the Radio Technical Planning Board approved unanimously a report outlining standards of transmission and frequency allocations for a nationwide television service. This report, the blueprint for post-war expansion of the video art, is now being reviewed by the RTPB and will be placed before the Federal Communications Commission for action.

Since the report represents the unanimous opinion of the leading technical figures in the television field, it is believed that the recommendations will be adopted without major changes. The following summary and interpretation have been prepared by the editors from the records of the Television Panel and its six Committees.**

The Television Panel, the first RTPB Panel to complete its work, stems from the National Television System Committee, which drew up the television standards now officially sanctioned by the FCC. The Panel has substantially reaffirmed the NTSC television standards and has gone on to consider the frequency allocation problem.

TABLE I—POSSIBLE ALLOCATIONS IF 26 CHANNELS ARE USED IN THE BOSTON TO WASHINGTON AREA

Market	Channels	No. Present Stations	CP's Requested	Not Yet Applied For	Total
New York City	1, 2, 4*, 6, 8, 11, 12, 14, 16, 18, 20, 22	3	2	7	12
Philadelphia	3, 7, 9, 13, 15, 17, 19, 21, 23	1	2	6	9
Boston	1, 2, 4, 6, 8, 11, 12, 14, 16, 18	0	0	10	10
Washington, D. C.	1, 2, 4, 6, 11, 12, 14, 16	1	2	5	8
Baltimore	8, 18, 20, 22	0	0	4	4
Providence	10, 19, 21	0	0	3	3
Hartford	5, 9, 15	0	0	3	3
Schenectady, Albany, Troy	3, 7, 13, 17	1	0	3	4
Scranton, Wilkes-Barre	10, 26	0	0	2	2
Springfield, Holyoke	24	0	0	1	1
New Haven	25	0	0	1	1
Worcester	23, 25	0	0	2	2
Allentown, Bethlehem, Easton	24, 25	0	0	2	2
Lowell, Lawrence	25	0	0	1	1
Syracuse	4, 6, 14	0	0	3	3

Note: This tabulation is only one of many possible allocation plans. Channels could be assigned anywhere in the general area of the designated market.
* Frequency change of existing transmitter.

Proposed Frequency Allocations

The recommendations for frequency assignments constitute the most radical proposal of the RTPB Panel report. Allocations are proposed for commercial channels in the region from 50 to 246 Mc, for relaying (network and outside pick-up connections) in the region from 162 to 3000 Mc, and for experimentation in the region from 600 to above 10,000 Mc.

The channel width proposed for commercial broadcasting remains at its present value, 6 Mc. For relaying, channels of 10-Mc and 20-Mc widths are proposed, and for experimentation, channels of 20-Mc width.

The proposed allocation for com-

** The members of the RTPB Television Panel are: D. B. Smith (*Philco*) chairman; I. J. Kaar (*GE*), vice chairman; George Town (*Stromberg Carlson*), secretary; G. L. Beers (*RCA Victor*); F. J. Bingley (*Philco*); B. Ray Cummings (*Farnsworth*); A. B. DuMont (*DuMont Labs*); O. B. Hanson (*NBC*); J. D. Reid (*Crosley*); Peter Goldmark (*CBS*); M. L. Levy (*Emerson*); A. F. Murray (*Hughes Productions*); C. A. Priest (*GE*); R. H. Manson (*Stromberg Carlson*); J. E. Brown (*Zenith*); D. G. Fink (*Electronics*); H. R. Lubcke (*Don Lee*); W. A. MacDonald (*Hazeltine*); T. B. Grenier (*Metropolitan Television*); C. R. Nobles (*Westinghouse*); Jean Brand (*Raytheon*); P. J. Larsen (*SMPE*); R. J. Rockwell (*Crosley-WLW*); D. A. Quarles (*Bell Labs*); J. R. Poppele (*Bamberger-WOR*); H. G. Boyle (*N. A. Philips*); N. P. Case (*Hamilton*); H. S. Frazier (*NAB*); E. Labin (*Federal*); and W. Auerbacker (*Radio Television Institute*). In addition, 18 alternates and 21 observers were attached to the Panel, but did not vote. The six committees of the Panel had 60 additional members and alternates.

TELEVISION

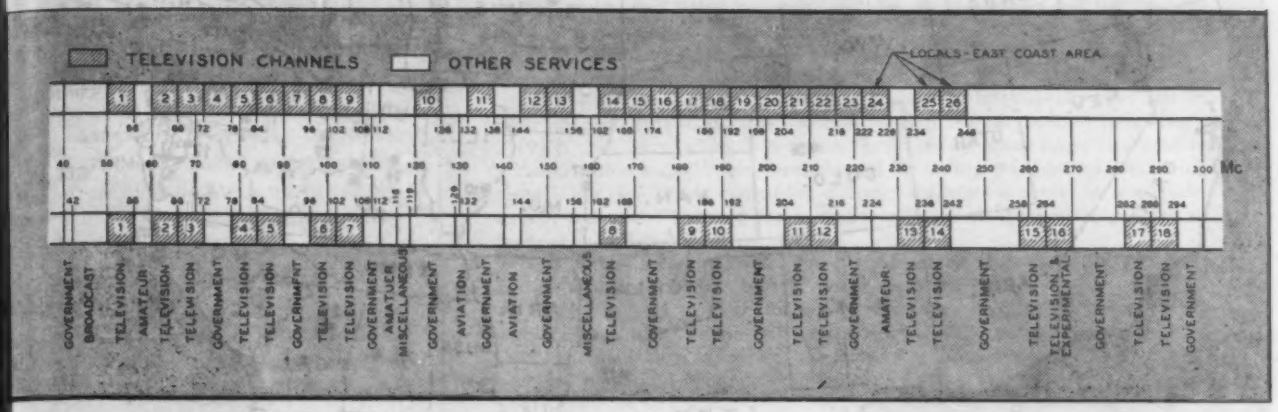


FIG. 1—The proposed frequency allocation for commercial television broadcasting is shown in the upper bar providing 26 channels, as contrasted with the present allocation shown in the lower bar and providing 18 channels. Individual station bandwidths are the same in each case, 6 Mc. Relaying channels and experimental channels are not shown here

mercial broadcasting is shown in Fig. 1. The present allocation (lower bar in the figure) consists of 18 six-megacycle channels from 50 to 294 Mc. The proposed allocation (upper bar) suggests the addition of 8 six-megacycle channels, making 26 channels in all, extending from 50 to 246 Mc. According to this proposal, television would occupy about 80 percent of the space from 50 to 246 Mc. Gaps are left for the present amateur bands and for aviation, government, and miscellaneous services.

The justification for this large amount of ether space is found in the requirements for a national allocation of television service. The first 30 metropolitan markets, defined by the U. S. Department of Commerce and roughly spotted in Fig. 2, are used as the basis of the Panel's plan. The most critical region from the allocation standpoint is the eastern seaboard from Boston to Washington, within which nine of the thirty markets are located. Figure 3 shows a possible allocation of one station to each of these nine markets, using four channels. The interference radius is shown as 170 miles.

To provide more than one station per city, and to offer service in smaller cities in the same region, a large number of additional channels are required. Table I shows a possible allocation of the 26 proposed channels to the eastern seaboard which would allow 12 stations in New York, 10 stations in Boston, nine stations in Philadelphia and eight stations in Washington (the primary markets). The table shows a total of 65 stations in 15 market areas. (The same allocation plan would provide 12 stations in Chicago, nine in Detroit, eight in Pittsburgh, seven in Cleveland, and a smaller number in the nearby smaller communities.)

This is television service on a scale not thought of before the war. In view of the present level of production and employment in the industry, supplying the equipment for such a system should prove easy, provided only that the public is willing to pay for it. Public acceptance depends not only on the technical excellence and availability of service, but also on the quality and quantity of program material.

Relaying and Experimental Channels

The cost of television programming is such that network connections are considered essential, so that several stations may share the cost.

To prepare for relaying requirements, as well as to permit studio-to-transmitter service and outside pick-up, the RTPB Panel has proposed allocations for commercial television relay service. The channels are classified in three groups: Group B, consisting of a number of 12-Mc channels from 162 to 294 Mc (which will eventually be displaced by assignments to television broadcasting); Group C consisting of twenty 10-Mc channels in a continuous band somewhere between the limits 300 and 1000 Mc; and Group D consisting of twenty 20-Mc channels in a continuous band somewhere between the limits 1000 and 3000 Mc. Proposed assignments for relaying constitute 600 Mc in all, or about 22 percent of the space between 300 and 3000 Mc. The remaining 78 percent is more than sufficient to take care of other needs, including post-war radar and similar wideband services.

The final allocation proposal has to do with experimental stations. The Panel is on record to the effect that an improved system of television should be investigated by ex-

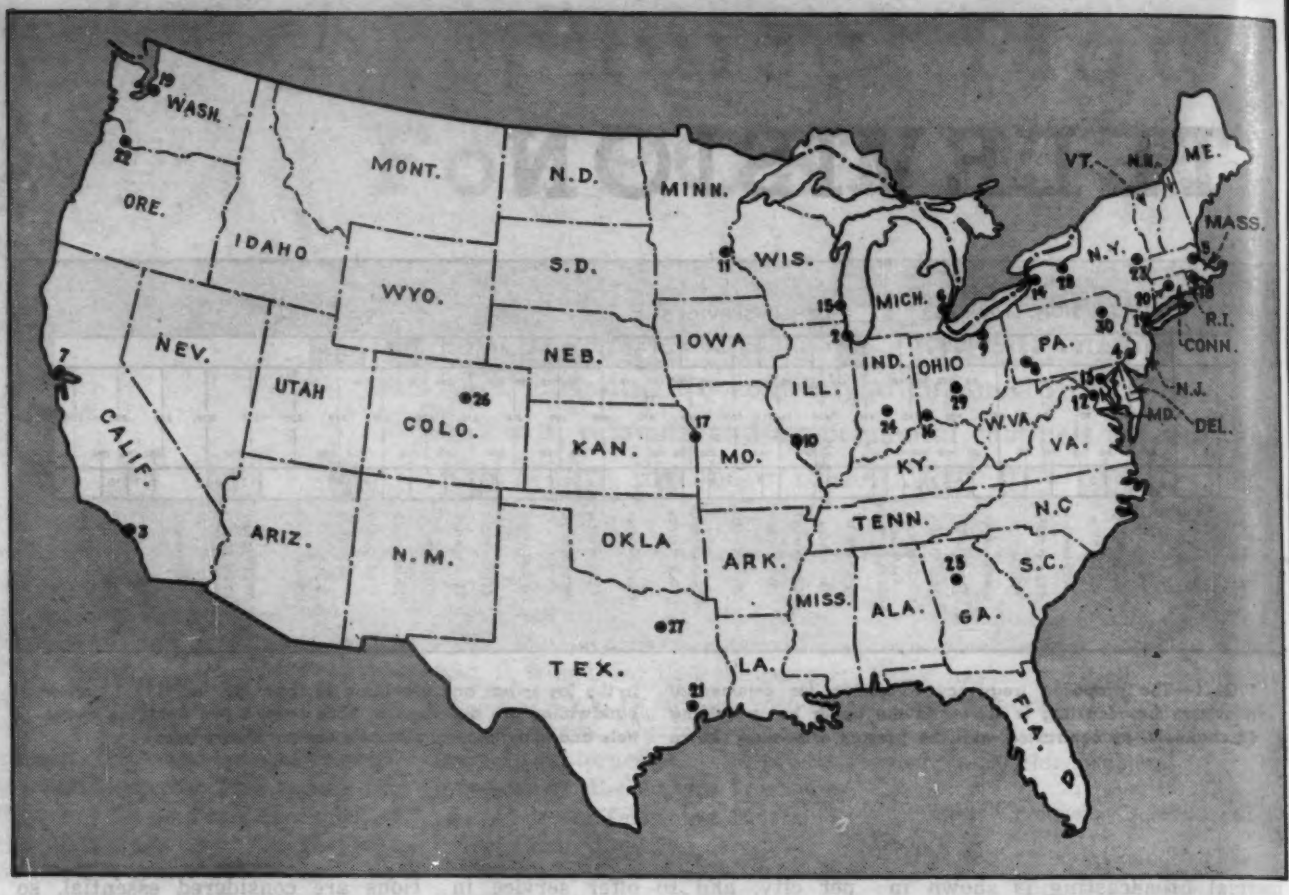


FIG. 2—Basis of the RTPB Television Panel's plan is the assignment of channels to stations in the first 30 metropolitan markets, as defined by the U. S. Department of Commerce. Markets roughly spotted on the map include: (1) New York; (2) Chicago; (3) Los Angeles; (4) Philadelphia; (5) Boston; (6) Detroit; (7) San Francisco; (8) Pittsburgh; (9) Cleveland; (10) St. Louis; (11) Minneapolis; (12) Washington; (13) Baltimore; (14) Buffalo; (15) Milwaukee; (16) Cincinnati; (17) Kansas City; (18) Providence; (19) Seattle; (20) Hartford; (21) Houston; (22) Portland; (23) Albany; (24) Indianapolis; (25) Atlanta; (26) Denver; (27) Dallas; (28) Rochester; (29) Columbus; (30) Scranton

perimentation. To provide for such experimental work, it was recommended that 30 channels, each 20-Mc wide, should be assigned in a continuous band between 600 and 2000 Mc. Although it is recommended by the Panel that no standards for use in such channels be set up at present, calculation shows that a 20-Mc channel (maximum video sideband 18.25 Mc) is capable of accommodating a picture of 1100 lines, possessing detail comparable to professional 35-mm motion pictures.

The experimental stations to some extent may occupy the same channels as relay stations. Allowing 50 percent duplication, the allocation of experimental facilities adds 300 Mc of space to the previously mentioned 600-Mc requirement for relaying and lifts the total requirement for television space to 33 percent in the region from 300 to 3000 Mc.

Additional allocations for experimentation are suggested in the region above 3000 Mc, including a continuous band of sixty 20-Mc channels in the region from 3000 to 10,000 Mc, and an unspecified number of 20-Mc channels above 10,000 Mc. The channels above 3000 Mc are desired primarily for experimentation with television relaying, rather than for experimental broadcasting. Here

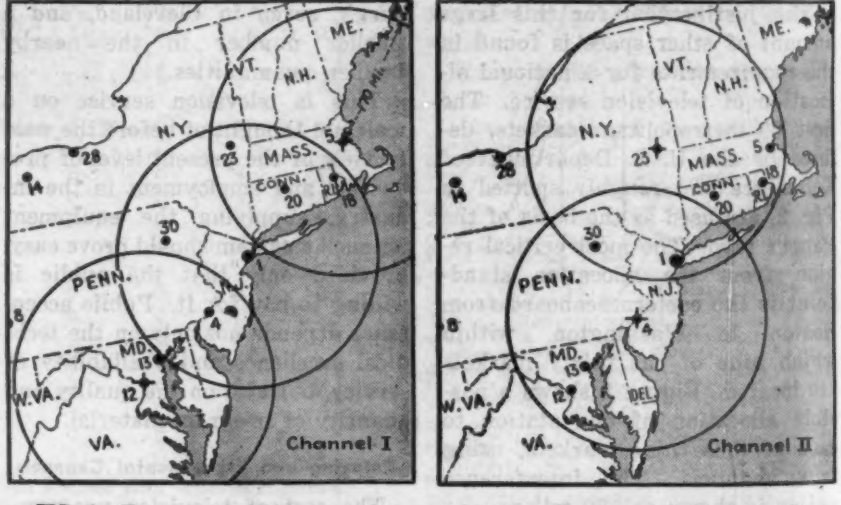


FIG. 3—The most critical region, from a television allocation standpoint, is the eastern seaboard from Boston to Washington, within which nine of the 30 major

again the requirements for space are great, but the percentage of the available space is not excessive.

RTPB Proposed Television Standards

The RTPB Panel has reviewed the standards governing commercial television broadcasting (NTSC-FCC standards) and has reaffirmed most of them. Two basic changes have been made. The alternative use of frequency modulation for the picture and synchronizing signals has been eliminated, and the specifications for frequency modulation of the associated sound signal have been modified. In all other respects, including the scanning specifications, the RTPB recommendations coincide with the existing standards.

The complete list of standards is given in Table II. The explanation of each standard has appeared previously in an ELECTRONICS report (February 1941, p. 17) on the NTSC proceedings. They have also been described in detail in the book "Television Standards and Practice" (McGraw-Hill, New York, 1943). In the interest of completeness in this report, a brief discussion of the standards is presented.

The first four standards have to do with the 6-Mc television channel, shown in Fig. 4. These standards are identical in all respects to the NTSC-FCC values. The 6-Mc channel permits vestigial sideband picture transmission with a maximum video sideband of about 4.25 Mc. The sound carrier is spaced 4.5 Mc from the picture carrier, rather than 1.25 Mc (which would be possible if the sound carrier were moved from the right edge of the diagram to the left edge) because the effect of cross-modulation between carriers is not noticeable with the wide spacing and would be visible with the narrower spacing.

The next four standards, on scanning specifications, are also identical with the NTSC-FCC values. The picture scanning figures remain at 525 lines, 30 frames per second, interlaced two-to-one. It was the concensus of Committee 3 of the Panel, which investigated the matter, that these values represented the best values with which to employ the full capabilities of the

TABLE II—PROPOSED STANDARDS

(1) The width of the standard television broadcast channel shall be 6 Mc.

(2) It shall be standard to locate the visual carrier 4.5 Mc lower in frequency than the unmodulated aural carrier.

(3) It shall be standard to locate the unmodulated aural carrier 0.25 Mc lower than the upper frequency limit of the channel.

(4) The standard visual transmission amplitude characteristic shall be that shown in appended Drawing I (Fig. 4)

(5) The standard number of scanning lines per frame period shall be 525, interlaced two-to-one.

(6) The standard frame frequency shall be 30 per second and the standard field frequency shall be 60 per second.

(7) The standard aspect ratio of the transmitted television picture shall be 4 units horizontally to 3 units vertically.

(8) It shall be standard, during active scanning intervals, to scan left to right horizontally and from top to bottom vertically, at uniform velocities.

(9) It shall be standard in television broadcasting transmission to modulate a carrier within a single television channel for both picture and synchronizing signals, the two signals comprising different modulation ranges in amplitude.

(10) It shall be standard that a decrease in initial light intensity cause an increase in radiated power.

(11) It shall be standard that the black level be represented by a definite carrier level, independent of light and shade in the picture.

(12) It shall be standard to transmit the black level at 75 percent (with a tolerance of plus or minus 2.5 percent) of the peak carrier amplitude.

(13) It shall be standard to use frequency modulation for the television aural transmission, with a maximum frequency swing of 25 kc.

(14) It shall be standard to pre-emphasize the aural transmission in accordance with the impedance-frequency characteristic of a series inductance-resistance network having a time constant of 50 microseconds.

(15) It shall be standard in television broadcast transmission to radiate a signal in conformity with the appended drawing "Television Synchronizing Waveform," Committee 2, Panel 6, RTPB, March 15, 1944 (Fig. 5), as modified by vestigial sideband operation as specified in Drawing I of the FCC "Standards of Good Engineering Practice," dated April 30, 1941.

(16) The time interval between the leading edges of successive horizontal pulses shall vary less than one half of one percent of the average interval.

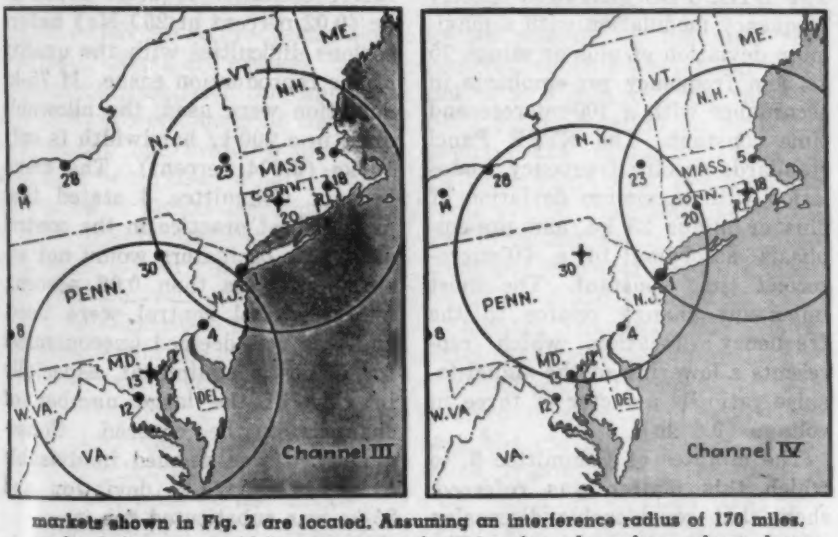
(17) It shall be standard in television transmission that the rate-of-change of the frequency of recurrence of the leading edges of the horizontal synchronizing signals be not greater than 0.15 percent per second, the frequency to be determined by an averaging process carried out over a period of not less than 20, nor more than 100 lines, such lines not to include any portion of the vertical blanking signal.

(18) It shall be standard to rate the visual transmitter in terms of its peak power when transmitting a standard television signal.

(19) Modulation of the visual transmitter, the radio-frequency signal amplitude shall be 15 percent or less of the peak amplitude, for maximum white.

(20) It shall be standard to employ an unmodulated radiated carrier power of the aural transmission not less than 100 percent nor more than 150 percent of the peak radiated power of the picture transmission.

(21) It shall be standard in television broadcasting to radiate signals having horizontal polarization.



markets shown in Fig. 2 are located. Assuming an interference radius of 170 miles, each of the nine could have a station by using four channels as shown here

4.25 Mc video sideband previously mentioned.

F-M Video Not Permitted

Standard number 9, relating to the type of modulation to be used in transmitting the picture, has been changed to permit amplitude modulation only. The NTSC-FCC version of this standard permitted the use of either amplitude or frequency modulation for picture and synchronizing signals. Experience has shown, since the NTSC investigation, that frequency modulation has serious limitations in broadcasting the picture, due to the effects of multipath transmission.

When multipath effects are present, the direct wave and a wave reflected from a structure off the direct path tend to cancel or reinforce each other by wave interference, depending on the relative phases of the signals. When frequency modulation is employed, the arrival of one value of the carrier frequency may be delayed in the reflected path just enough to interfere with (and possibly cancel) the same value of the carrier frequency transmitted by the direct path. The effect is particularly pronounced when frequency modulation is used for the sync signals, since the maximum and minimum amplitudes of the sync correspond to two discrete carrier frequency values. Demonstrations showed that multipath transmission may result in total loss of the sync signal when f-m is used, whereas no such serious effect occurs when a-m is used.

The effect of multipath transmission is also serious in the picture itself. In this case, the effect of multipath transmission is to produce a beat-note pattern which has no evident relationship to the picture content and flickers over the screen in a distracting fashion. The same multipath conditions, when a-m is employed, produce a ghost image displaced from the true image but similar to it in form. Such a-m ghosts, while troublesome, are much less annoying than the f-m ghosts. Hence it was concluded by Committee 2 of the Panel, which studied the matter, that frequency modulation was impractical for picture broadcasting. (It should be noted, however, that f-m is highly suitable for *relay* picture transmissions, where the use of directive transmitting and receiving antennas eliminates the effect of reflected signals.)

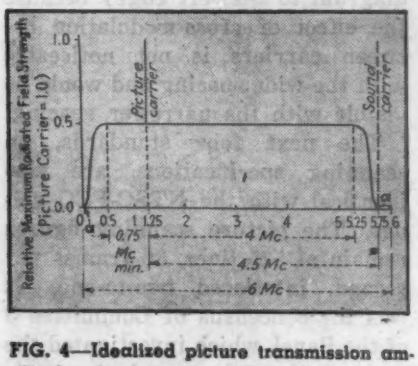


FIG. 4—Idealized picture transmission amplitude characteristic. The relative field strength outside the picture side bands (at a) is not to exceed 0.0005. Details are discussed in the text

The next three standards, relating to the polarity of transmission, d-c transmission, and the percentage of carrier amplitude devoted to sync signals, are identical with the NTSC-FCC standards. Here again Committee 2 agreed that these methods of transmission represented the best practice known to the art, and should be preserved for post-war use. The numerical values stated in the standards are illustrated in the sync-signal waveform, shown in Fig. 5.

Audio Standards Substantially Changed

The next standards, numbered 13 and 14, relate to the transmission of the associated sound signal. Strangely enough it is only in these standards, which do not relate to the television problem proper, that any substantial changes appear. The NTSC-FCC standards specify frequency modulation with a maximum deviation of plus or minus 75 kc, and frequency pre-emphasis in accordance with a 100-microsecond time constant. The RTPB Panel standards specify frequency modulation with maximum deviation of plus or minus 25 kc. and pre-emphasis according to a 50-microsecond time constant. The most important change relates to the frequency deviation, which represents a lowering of the signal-to-noise ratio by a factor of three in voltage (9.6 db).

The minutes of Committee 3, to which this matter was referred, show that considerable discussion centered on this question. The NTSC had standardized on a deviation of 75 kc with the tacit understanding that only the Group A channels (up to 108 Mc) would be available for broadcasting in the initial stages. The RTPB, as shown earlier in this report, was faced by the definite prospect of using channels as high as 250 Mc. Between 100 Mc and 250 Mc there has been found to exist a dividing line above which the frequency drift of the receiver local oscillator becomes a serious factor. It has been appreciated for some time that frequency-modulated sound transmission requires more precise tuning than amplitude-modulated signals, because the wider spectrum of the f-m transmission occupies fully the bandwidth allotted to it in the receiver and because full noise suppression is obtained only when the f-m signal is centered on the discriminator characteristic. Thus the receiver drift problem operates against proper reception of f-m sound signals on the channels above 100 Mc.

Two proposals were offered to solve the problem. One was to revert to amplitude modulation for the sound channel, while retaining the receiver bandwidth at the 200-kc value. This would permit the receiver oscillator to drift plus or minus 80 kc (about 0.03 percent at 250 Mc) without affecting the strength or quality of the sound transmission. The other alternative was to reduce the deviation of the f-m transmission, but likewise retain the full bandwidth at 200 kc. The 25-kc deviation permits the receiver oscillator to drift about 60 kc (0.02 percent at 250 Mc) before serious difficulties with the quality of the reproduction ensue. If 75-kc deviation were used, the allowable drift in a 200-kc bandwidth is only 10 kc (0.004 percent). The members of Committee 3 stated that present best practice in the control of 250-Mc oscillators would not assure drift less than 0.02 percent, unless crystal control were used, and this was deemed uneconomical for domestic equipment, especially in view of the large number of channels to be covered. Consequently it was deemed inadvisable to retain the 75-kc deviation and 25-kc was substituted for it.

Another problem encountered in

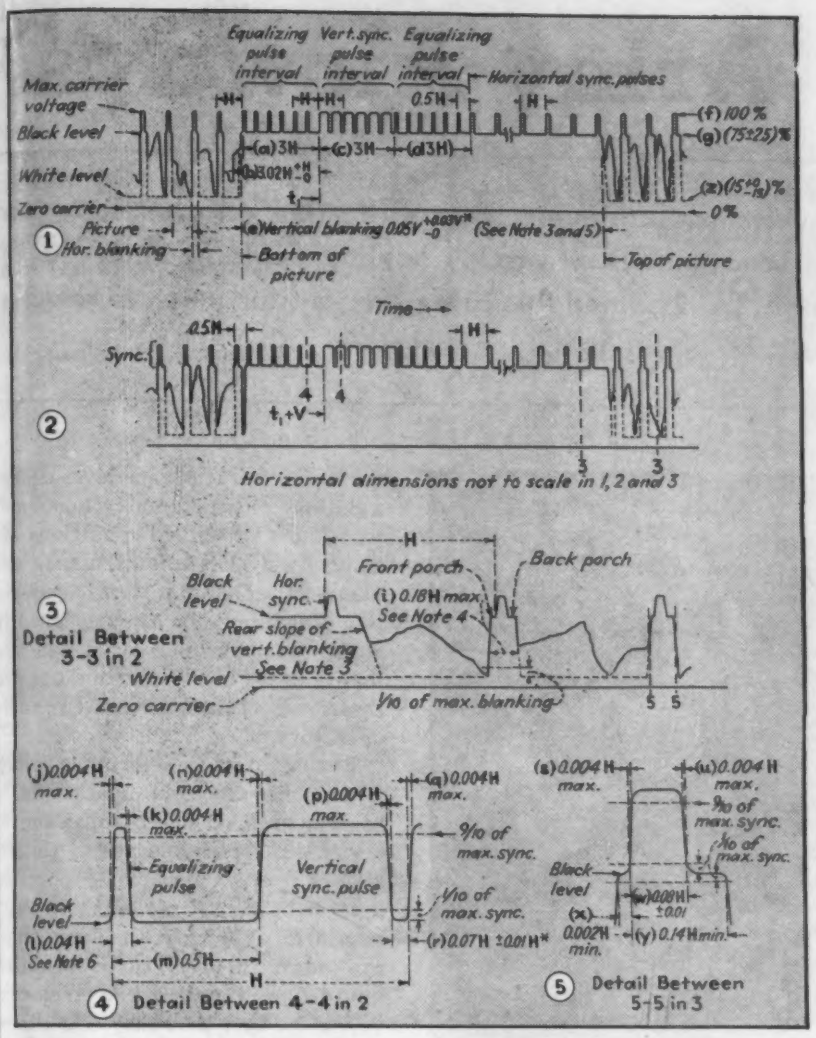


FIG. 5—Recommended television synchronizing waveform

Notes: (1) *H* equals time from start of one line to start of next line; (2) *V* equals time from start of one field to start of next field; (3) Leading and trailing edges of vertical blanking should be complete in less than 0.1 *H*; (4) Leading and trailing slopes of horizontal blanking must be steep enough to preserve minimum and maximum values of $(x+y)$ under all conditions of picture content; (*5) Dimensions marked with an asterisk indicate that tolerances given are permitted only for long time variations, and not for successive cycles; (6) Equalizing pulse area shall be between 0.45 and 0.5 of the area of a horizontal sync pulse.

f-m transmission is the audio distortion which can be produced when multipath effects are present. Such distortion arises from the cancellation of two components of the carrier signal, one arriving directly, the other by a reflected path. When the reflected signal is comparable in strength to the direct signal, noticeable distortion may occur. This problem was thoroughly discussed by Committee 3. This effect was considered to be of small importance compared with the receiver-drift problem.

The reduction of the time constant from 100 to 50-microseconds was recommended on the advice of the broadcasters, who indicated that the 100-microsecond characteristic introduces somewhat excessive peaking of the high frequencies, causing the studio operator to ride gain at a low value to avoid overmodulation on high-frequency peaks. It was believed that the lower value of 50 microseconds would permit the studio gain control to be set safely at a higher value, and thus obtain more efficient use of the sound transmitter.

Standard number 20, which states the relative power of the picture and sound transmission, was changed to take into account, in part, the reduced deviation in the sound transmission. The NTSC-FCC standard specifies that the sound radiated power shall be from 50 to 100 percent of the picture radiated power. The RTPB Panel recommendation is that the sound-radiated power be increased to a value from 100 to 150 percent of the picture power. This amounts to maximum increase of 3 times in power (about 3 db), which compensates partly for the 9-db loss due to lowered deviation. It was believed that the noise-reduction inherent in f-m transmission was sufficient to take care of the 6 db difference in all parts of the service area.

Sync Signal Waveform

The next three standards (15, 16 and 17) specify the synchronizing signal waveform and certain tolerances. The only change here is another elimination of an alternative.

The NTSC-FCC standards specify the serrated vertical synchronizing waveform of Fig. 5, but they also permit an alternative form, the so-called 500-kc vertical sync. The deliberations of Committee 2 revolved about the relative merits of the two systems. It was brought out that the resonant band-pass circuit used to separate the vertical pulses in the 500-kc signal have twice the band-width of the low-pass integrating circuit used with the serrated pulses of Fig. 5, and that the noise accepted by the former circuit might therefore be greater, depending on the noise spectrum actually present. But the principal factor favoring the serrated pulse was the fact that it offered excellent performance when used with a newly developed a-f-c vertical sync circuit, which so improves the general performance of the synchronization system as to provide solid synchronization even when the signal strength is so low that the picture is barely recognizable. In possession of such a satisfactory solution of the sync problem, the Committee voted to eliminate the alternative form of sync pulse in the interest of simplification of the standards.

The synchronization waveform shown in Fig. 5 is identical in all numerical values and shapes to the standard NTSC-FCC waveform. Minor corrections and additions to the dimensions have been incorporated in the interest of greater precision and to clarify the meaning of the specifications. The tolerance standards 16 and 17 were set up by

(*Continued on page* 164)

Army Airways

Army Air Force affiliate provides point-to-point service, weather information, aeronautical navigational aids and coordination at various landing fields in domestic and foreign theaters, facilitating military flying and pointing the way for post-war development of international air travel

Typical AACS radio station at major AAF airdrome. The operator at the left exchanges weather data with other bases, the one in the center handles arrival and departure messages, the man at the right maintains contact with aircraft enroute and the man in the foreground is the supervisor

REFLECTING the rapid rise in military aviation, and foreshadowing the future development of air travel together with the communications system which will make it possible, is the Army Airways Communications System with headquarters in the City Hall Building at Asheville, North Carolina.

The AACS, a worldwide organization, is part of the Army Air Force. Its immediate objective is to make military flying as safe, foolproof and reliable as is humanly possible in wartime. To this end the organization operates a vast array of wire and radio communications facilities, direction-finding and range-beacon stations, weather stations and other radio facilities and also coordinates many similar services at various landing fields.

The activities of the AACS will have definite value in peace-time military aviation and, despite the fact that military airways do not necessarily follow routes desirable for commercial service, should also prove useful in re-establishing commercial and civilian aviation in the post-war period.

Organization

The AACS is primarily an operating or service organization in which field activities are of paramount importance. The administrative headquarters are unobtrusive and practical; those responsible for administration are level-headed aviation or communications men who know what field conditions are beause they have flown planes and operated communication systems. Some have extensive experience in commercial communications and many have built and maintained their own stations as amateur radio operators.

Beause of the importance which is attached to field operations, a high degree of decentralization is desirable. Men operating control towers or, perhaps, portable marker-beacons, are "on their own" to a large extent. At the same time, the high degree of specialized knowledge which these men require, the fact that they often have very severe responsibilities, and that they are called upon to produce results regardless of the circumstances in which they find themselves calls for particularly dependable, resourceful and reliable personnel.

As a result of necessary decentralization, the usual array of "echelons" has been streamlined to the point where the remotest de-

This ugly duckling, consisting of a few boards, some rusty nails, a signal-light gun, a field telephone, a cot, a receiver and a transmitter served as a control tower at a Chinese field until more elaborate equipment arrived

Communications System

tachment is only a few layers removed from the top man. The headquarters in Asheville is the nerve center of the entire system. It is largely an administrative unit and coordinates its activities with those of the Army, Navy, the Civil Aeronautic Administration and our Allies. It establishes policies for the overall system.

So far as the AACS is concerned, the world is divided into 8 Wings for purposes of administration. In most instances, Wing Headquarters are located near the terminals of the various air-ferry and air-transport commands. In general, Wing Headquarters is responsible for the supervision and inspection of installations and equipment and for the establishment of policies relating to operations within the Wing. Each Wing is divided into groups, of which 24 exist at the present time. Of these, four are located in the continental United States and the balance in foreign countries.

A Detachment is a field operating unit charged with the responsibility of operating and maintaining one of the many AACS stations which may be located almost anywhere throughout the world. The Detachment is set up to provide operating and maintenance services only. However, in many cases members of a Detachment are required to perform additional services, such as installing and even constructing control towers and communications equipment, usually beause of their remoteness from normal facilities for such purposes.

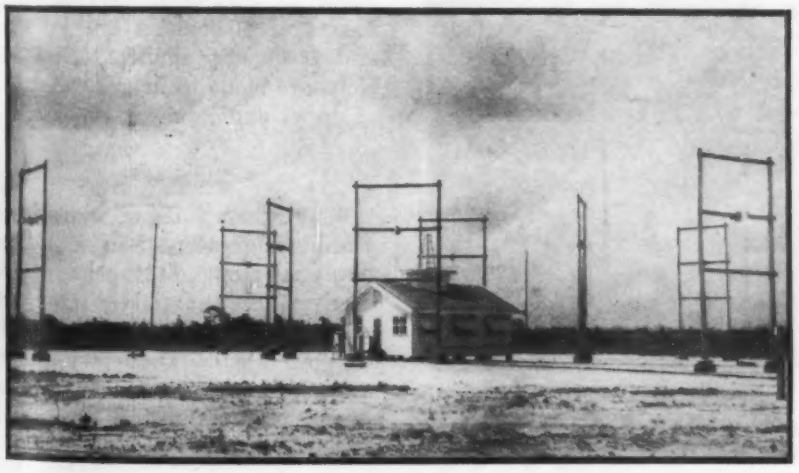
Flying freights find cargoes waiting, thanks to rapid exchange of information between AACS radio stations. Minimum delay at stops spells efficient operation

Such a streamlined organization is well adapted to carry out the activities in which the AACS is primarily engaged. Broadly speaking, these activities are three-fold: (1) to provide point-to-point communications throughout the world, especially with ground stations along military airways, (2) to collect, coordinate and disseminate weather information along military airways, and (3) to provide aeronautical navigational aids and various types of flight controls for aircraft operating between ground stations.

Problems

Numerous unusual and interesting problems confront the AACS and in each case a satisfactory answer must be found promptly. For example, the organization must maintain a continuous watch throughout the world for all military airways for whose operation it is responsible. It must establish communications quickly in war theaters and this may be a task of considerable proportions and difficulties in a war of a high degree of mobility. Although the Signal Corps is charged with the installation and major repairs of equipment, conditions sometimes make it necessary for AACS personnel to install and service equipment as well as to maintain it.

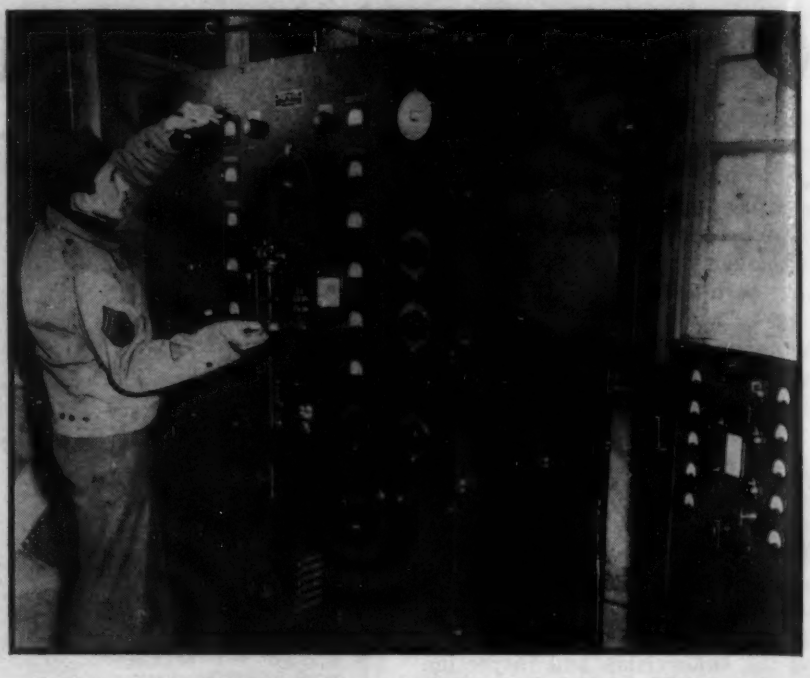
While it is necessary to be sure that our own personnel is adequately informed of weather and other conditions in which they are interested, it is equally important to keep such information from the enemy. This requirement imposes



Direction-finding stations like this, set up all over the world, give bearings to military aircraft hundreds of miles away

certain restrictions on the system, which do not exist to the same extent in commercial installations. To provide adequate weather information, it is necessary to operate weather stations throughout the world. The Weather Wing of the Army Air Force makes the observations from which weather reports are prepared, but the AACS serves as the transmission agency in disseminating this data.

These various requirements make it mandatory to have personnel resourceful in the field, for many improvisations may be required. The system is constantly in a state of change to cope with new conditions or to expand its service.



Radio-range transmitter in the far north, being checked by an AACS maintenance technician

Facilities

The wide variety of services rendered by the AACS requires that it employ practically all known means of communications.

In outpost detachments, where a new installation is just getting under way or where traffic is light, manually-keyed radio circuits are usually adequate. Such circuits are most useful where the traffic does not exceed about 100,000 words per month.

As traffic increases, manually-keyed radio circuits give way to automatic-keyed, high-speed radio circuits. This type of facility is used in stations at major terminals and generally handles from a million to a million-and-a-half words per month. Should point-to-point communications be limited to a few hours a day, due to ionosphere characteristics, automatic keying is particularly useful as it is often permissable for traffic to pile up while circuits are inoperative and then to push it all through during the period in which transmission characteristics are desirable.

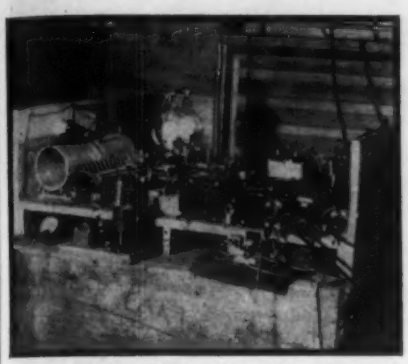
Point-to-point communication is used to send dispatcher notices to planes, for identifying planes, for location of planes during flight, to indicate to the next airport when planes are expected to arrive and to assure that the point of arrival has adequate facilities for feeding, housing, and otherwise taking care of the mission. Such point-to-point service is in continuous operation; periodic schedules are not adequate. In the average ground stations, radio operators customarily monitor and guard more than one frequency, although this service is not available in all installations. Communication is frequently carried on by means of 10-channel transmitters, and frequently multiple transmissions are made to insure the safety of crews and to check reports.

A complete airways radio station, serving aircraft shuttling over long waterhops in the South Pacific. A gasoline generator may be seen at the left of the hut and an antenna at the upper right

Teletype

Where the volume of traffic is appreciably greater than a million words per month radio-teletype systems replace automatic tape circuits. Teletype transmissions can take place at 60 words per minute and additional personnel and time are not required to code messages sent in this manner.

The extensive use which the AACS makes of teletype service and the rapid expansion which many of the communications centers undergo has produced some real problems in design and construction. To alleviate this trouble and, so far as possible, to relieve the field personnel of the responsibility for the engineering and planning of large permanent installations, Headquarters has undertaken the task of designing many teletype communication centers.



In the best amateur tradition, captured Jap parts are pressed into service to build an emergency transmitter

Upon being advised of the local facilities available for communications, Headquarters plans an adequate center and submits floor plans for the installation. Asheville even provides its field personnel with perspective photographs indicating general appearance and layout. These photographs aid field personnel in visualizing what the center should look like when it is built. This is accomplished by means of models of various pieces of teletype equipment and office furniture, built to scale and arranged to best meet requirements.

Facsimile

Facsimile picture transmission is employed not only to speed transmission but also to conserve the time of key personnel.

Since the number of well-trained weather-forecasters is limited, it is not possible to have a forecaster at each landing field. However, weather observers can be placed at the various landing fields. These men make continuous observations and transmit their meteorological data to a central station, at which a weather forecaster is located. On the basis of information sent to him, the weather forecaster can make his predictions and prepare a weather map. By means of facsimile such weather maps are transmitted from the key station to other stations in its region. By this method, the usefulness of trained weather forecasters is considerably increased.

Radiophone

Radio-telephone service is installed in airplanes primarily to enable them to communicate with control towers. Few point-to-point services employ radiophones since these are wasteful of frequency as compared to continuous-wave transmission. (Radio-telephone service is used to some extent in a number of Canadian Detachments.) Furthermore, the lack of secrecy of such equipment very definitely restricts the use which can be made of this class of service for military application.

Of course, both commercial-telephone and teletype-wire facilities are used to maximum advantage wherever these are available. Commercial services are used in the United States or other countries where such facilities exist.

Private Wire Facilities

At the various communication centers and airfields, private-wire facilities are used to supplement general or commercial facilities. For example: interphone or intercom equipment is often used, over a private wire line, to connect the engineering department, control tower, base hospital, commanding officer, fire house and crash crew. The purpose of such an emergency line is to provide reliable instantaneous service in the event of crash landing, fire, or other emergencies, without having to depend on commercial circuits. Interphone systems are set up so that stations are connected together throughout all hours of the day and are ready for immediate operation from any one of the interconnected stations. Any station can communicate immediately with any other station on the interphone system.

In addition to interphone or intercom private lines, a special crash-alarm is used at all permanent bases. This connects the tower, fire house, hospital and similar emergency services and important centers. This alarm system is set up so that all interconnected stations can be connected together simultaneously to receive the same message. This system is employed only for crash landings or similar emergencies.

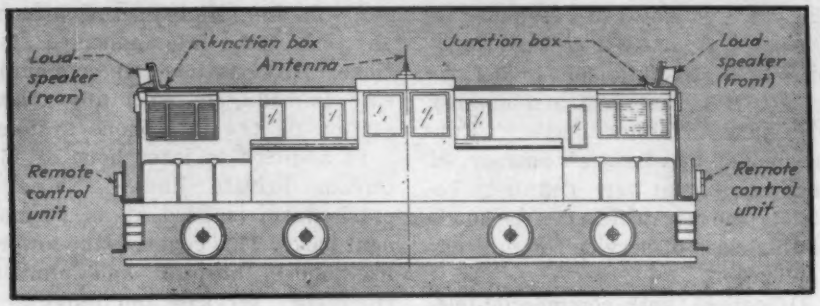
Equipment for the location, con-

(*Continued on page* 204)

Modern AACS control tower, perched like an eagle's nest on top of a hangar at a permanent Army air base

Electronic Communication

Description of typical radio, rail carrier and induction systems used for maintaining two-way telephonic contact. Advantages and disadvantages of each. Discussion of safety devices designed to indicate equipment failures



Space radio telephone equipment on a Diesel-electric locomotive, showing location of whip antenna, auxiliary remote-control units and loudspeakers. The installation may be operated by personnel on the ground or by trainmen

IN APPLYING radio and other electronic signaling principles as a means of increasing efficiency and safety in the railroad field, engineers have developed a number of practicable train communicating methods. While the various methods have as a common denominator the electronic tube, and incorporate basic circuits known to the majority of communications engineers, modes of operation differ widely. Each method has certain technical and operational advantages and disadvantages, and practical experience on American railroads has indicated the advisability of considering all methods carefully when selecting a system to meet a specific requirement.

The available train-communicating systems may be grouped under three general classifications, according to the signal propagation method employed:

(1) *Space Radio Systems,* in which radio wave energy is propagated into space by non-directional or directional antenna systems.

(2) *Rail Carrier Telephone Systems,* in which carrier signals, at frequencies usually below 10 kc, are applied primarily to the rails. Reception on mobile units is ordinarily by an inductive method, with pickup coils located in proximity to the rails.

(3) *Induction Radio Systems,* which utilize the combined induction and radiation fields generated by radio-frequency carrier-signal energy impressed on wayside conductors, such as electric power, telephone, or telegraph wires. Carrier signal energy may be inductively impressed on wayside conductors by loop antennas installed in mobile units, or by use of inductive or capacitive line-coupling methods at fixed stations.

Space Radio Systems

Space radio systems, by virtue of their inherent ability to operate without the use of wayside wires or other conductors extending along railroad right of ways, provide the most flexible and versatile means of train communications. As metallic signaling circuits are not required,

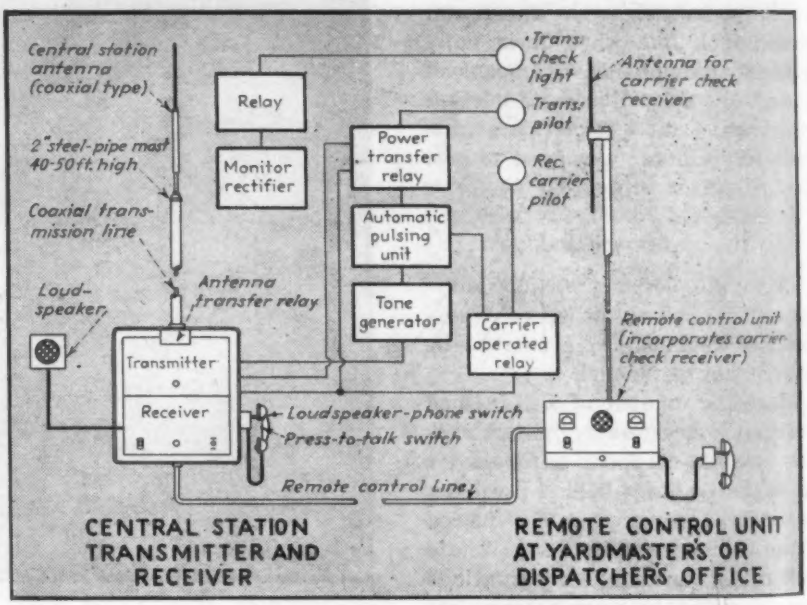


FIG. 1—Typical arrangement of central-station equipment employed in a space radio installation now in railway service

for TRAINS

By WILLIAM S. HALSTEAD

President
Halstead Traffic Communications Corp.
New York, N. Y.

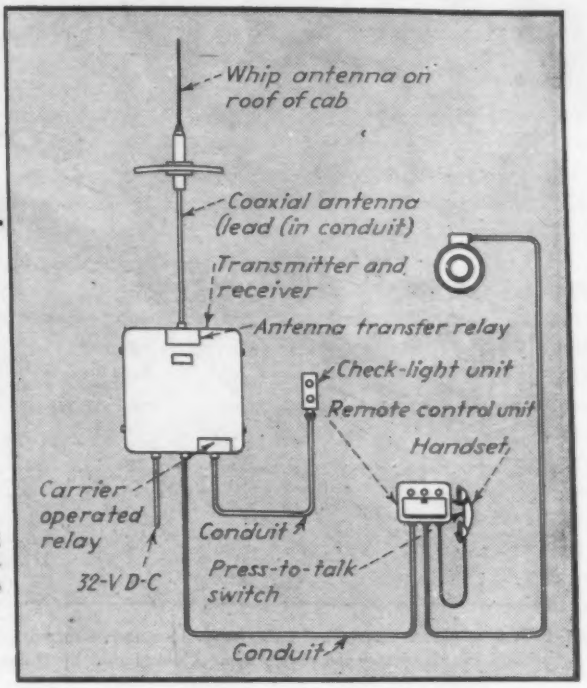


FIG. 2—Equipment used in the cab of a locomotive in a typical space radio installation

a space radio system will continue to function with full efficiency when wayside wires or tracks are damaged by storm, floods, or other causes and maintenance of positive communications along railroad right of ways is most urgently needed.

In the majority of railroad radiotelephone installations now in use, frequency-modulation equipment designed for operation at frequencies above 30 Mc is employed. In many instances, notably on the railway systems of government-owned ordnance plants, operation has been conducted in the 30–40 Mc band, with output power ratings of locomotive transmitters ranging from 25 to 50 watts. These installations for the most part utilize coaxial radiators at central stations to effect relatively uniform propagation of radio wave energy in all horizontal directions, thereby providing complete coverage of yards extending over comparatively wide areas.

Many of the railroad radio installations now in use comprise a central-station transmitter having nominal power output ratings ranging from 25 to 50 watts, although amplitude-modulated transmitters rated as low as 15 watts have been successfully used for yard operations. The transmitter, its associated central-station receiver, and the coaxial antenna are usually installed at an elevated point or other suitable location near the center of the railroad yard, with telephone line connections to a remote control unit at a yardmaster's or dispatcher's office as indicated in Fig. 1.

Receiving equipment on locomotives is cooperatively associated with transmitting equipment and normally is mounted in the same case, as shown in Fig. 2. A relay is employed to transfer the antenna from receiver to transmitter. In order to provide an audio signal of good intelligibility within the cab, an audio amplifier having a power output rating of at least 3 watts is ordinarily used in the receiver, while the loudspeaker employed in locomotive cabs is usually of the re-entrant type. Flexible "whip" antennas are employed, as far as is known, in all locomotive radiotelephone installations, so the antenna will not be damaged in entering roundhouses or passing under power lines and other overhead structures.

Power Supplies and Shock Mounts

Much of the railroad radiotelephone equipment now installed on Diesel-electric locomotives in ordnance plants and elsewhere is operated on a separate 6-volt storage battery, with a belt-driven generator being employed to charge the radio battery during periods in which the Diesel motors are in operation. Voltage regulators are used to maintain proper charging rate, as in the conventional electrical systems of automobiles.

Because of the prevalence of 32-volt d-c power sources on practically all steam locomotives and on many locomotives of other types, it is often desirable to provide radiotelephone equipment designed for 32-volt d-c operation.

All mobile transmitting and receiving units must be protected against the shock and vibration of locomotive service by means of shock mounts of suitable type. On steam locomotives employed in yard areas, proper shock-mount design is of considerable importance as both shock and vibration are of relatively great amplitude and of three-dimensional character. The impact experienced when a yard locomotive moves against a long string of loaded freight cars is often of considerable magnitude and may cause serious damage to components if adequate cushioning of shocks is not afforded.

In addition to the need for adequate protection against shock and vibration, it is important that locomotive radio equipment, on steam engines especially, be properly housed in order to protect components from the damaging effects of water and dampness, as well as from such trouble makers as carbon particles and corrosive gases.

Fail-Safe Provisions

The circuits employed in railroad radio equipment now in service in ordnance plants and at other locations are similar, in general, to

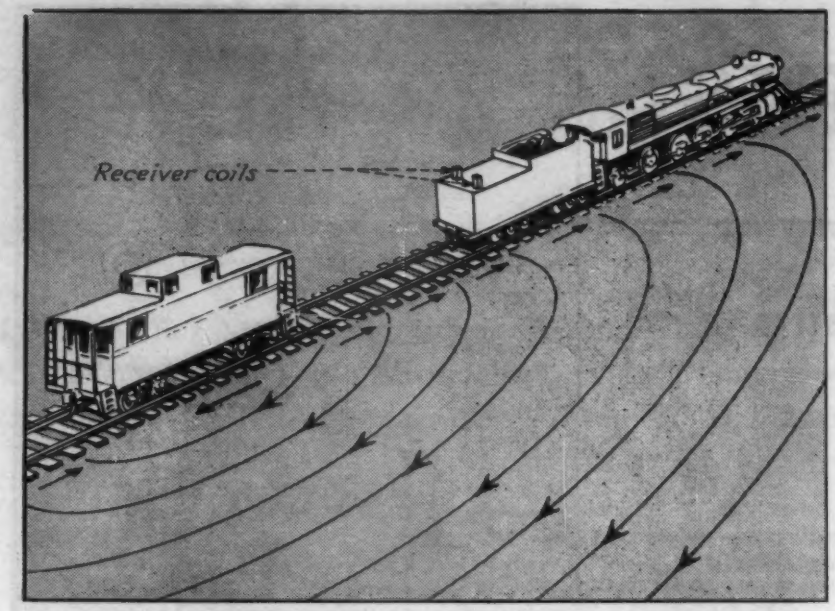


FIG. 3—Current flow from caboose to locomotive through rails and back through ground in rail carrier telephone system developed by Union Switch and Signal Co.

those utilized in conventional police radio apparatus. However, in certain instances, protective checking circuits have been incorporated in order to provide an equivalent of the normally closed-circuit principle employed in railway signaling practice. An example is the standard semaphore arm, which drops by gravity to the "stop" position when power fails; the engineer of an approaching train must then follow a precautionary procedure.

Instructions given by radiotelephone to an engineer must be followed in minute detail unless they are countermanded. Should central-station equipment fail after issuance of orders, or should locomotive receiving apparatus become inoperative for any reason, the engineer, if not advised of such failure, would proceed to follow the original instructions regardless of attempts by the dispatcher to change these orders.

Typical Audio-Visual Checking System

In railroad radiotelephone systems developed by engineers of the Halstead Corporation, checking signals are continuously transmitted from the central station or other control station at intervals of several seconds. In locomotive cabs, these signals are reproduced by cab loudspeakers and control the operation of visual indicators to provide audio-visual indication of proper operation of the system.

owned ordnance depots, such as the Kingsbury Ordnance Plant, a tone signal of 1000 cycles is utilized. In other installations, frequencies ranging from 180 to 1000 cycles have been employed.

In order to prevent interference between the automatically-transmitted checking signals and voice signals from mobile units or secondary stations operating on the same carrier frequency, a carrier-operated lock-out relay in the central-station receiver automatically suspends pulse transmission during periods in which signals are being transmitted by mobile units or secondary stations.

An overall carrier-check is also utilized at the central-station control point to provide an indication of proper emission of checking and

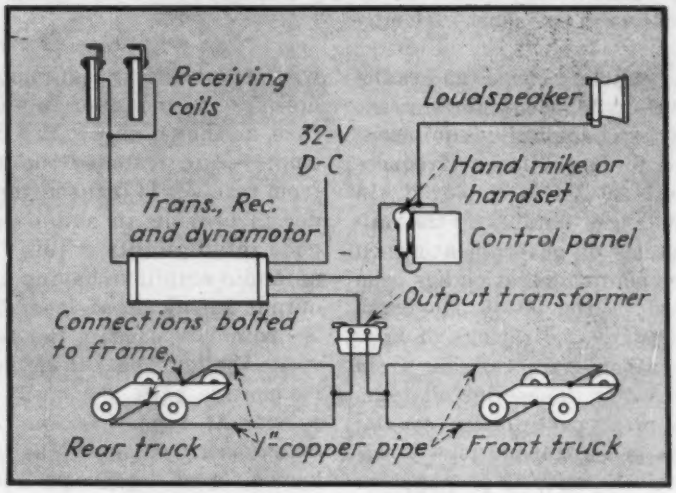


FIG. 4—Block diagram of two-way rail carrier telephone system used on caboose by Union Switch and Signal Co.

In a system of this type, which has been successfully utilized in some ordnance plant installations over a period of two years, carrier wave energy is transmitted from the central station at periodic intervals by means of an automatic pulsing device which momentarily keys the transmitter at predetermined intervals. Concurrently with emission of the carrier, a tone signal is impressed on the input circuit of the transmitter. In locomotive cabs, the recurrent pulse signal actuates a check light, while the tone signal is reproduced by the cab loudspeaker. The frequency of the tone signal is such that it may be heard above normal background noise within a cab. In some government-

voice signals by the central-station transmitter. In some of the railroad radio installations now in service, this check is provided by means of a meter and a carrier-operated signal light incorporated in a carrier-check receiver located at the remote-control point.

A system of this general type provides a check on overall operation of the radio control system. In event of failure of the central-station transmitter, or any portion of the locomotive receiver, including the loudspeaker, the audio-visual signals are not repeated in the cab, thereby warning the engineer that the radio system is inoperative.

In some locomotive radiotelephone installations in which the

audio-visual checking system is employed, a carrier-operated relay, ordinarily connected in the audio gate or squelch circuit of the receiver, is utilized to control operation of the check light. In other instances, the check light is selectively controlled by a relay actuated by rectified signal energy of predetermined audio frequency. In this case, an audio-frequency filter having suitable bandpass characteristics is employed in connection with the audio output circuit of the receiver to accept the checking signal of predetermined frequency, such as 180 cycles, and to reject voice or other control frequencies. A signal rectifier, usually of the selenium or copper-oxide type, is then utilized to convert the audio-frequency checking signal into direct-current energy for operation of a relay, which controls the operation of the check light.

Protective radio control techniques are of particular value during freight classifying operations when a locomotive is pushing a long string of cars over a "hump" where freight cars are uncoupled, usually one at a time, and allowed to coast down to a particular track in the classification yard. Inasmuch as the engineer is frequently out of sight of critical yard operations in this case it is important for the engineer to know that he is in constant touch with the control point at the "hump" and that in event of equipment failure a positive indication will be given.

In applying radio communicating techniques on mainline trackage, several engineering problems are presented.[1] The substantially line-of-sight propagation characteristics of ultrahigh-frequency radio wave energy, particularly at frequencies above 300 Mc, will probably necessitate the use of automatic repeaters at certain points in urban areas and in mountainous country where obstructions in the transmission path, such as steel-frame buildings and hills, produce objectionable shielding effects. While the use of repeaters in this manner may involve a comparatively large number of wayside units, this equipment should also prove to be of value to wayside personnel who may be expected to utilize the repeater equipment for localized zone communications functions, thus sub-dividing the longitudinal radio-telephone network into a series of zones, each under local control as well as centralized control.

Automatic Repeaters on Main Lines

In repeater networks intended for operation at frequencies above 300 Mc, directional antenna systems with extremely high front-to-back ratios will probably be used for zone to zone work.

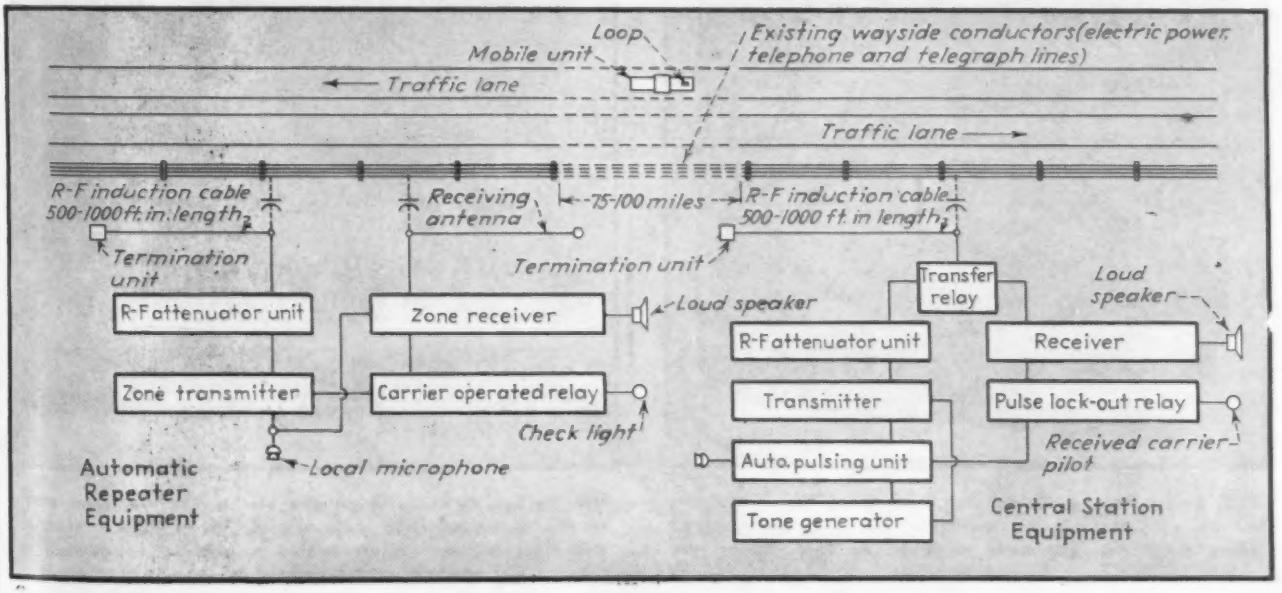
Radiotelephony is also expected to be of particular value in intra-train communications services, such as cab-to-caboose signaling. In this type of service, where distances are relatively short (ordinarily in the neighborhood of 7000 feet or less), the use of frequencies above 100 Mc and especially above 300 Mc appears logical.

Intra-train radio services are aided by the extended metallic ground path offered by the rails, as well as by the wave reflecting media presented by sides of hills and elevated wayside wire circuits where these are present. These factors are of particular importance at curves in railroad right of ways where hills and other obstructions in the line-of-sight transmission path between cab and caboose might otherwise cause objectionable suspension of communications.

Disadvantages of Space Radio

While space radio systems have maximum flexibility and are not dependent on wire and rail conductors along right of ways, the use of space radio, in the opinion of some railroad people, presents a serious problem in that the portions of the radio frequency spectrum where existing commercial equipment may be operated are already overcrowded. Also, any comprehensive use of radio equipment by the railroads must allow for the fact that most of the nation's principal rail transportation systems operate over

FIG. 5—Induction radio system for use on extended railway trackage requiring automatic repeater equipment, showing both inductive and capacitive methods of coupling to wayside conductors paralleling the tracks



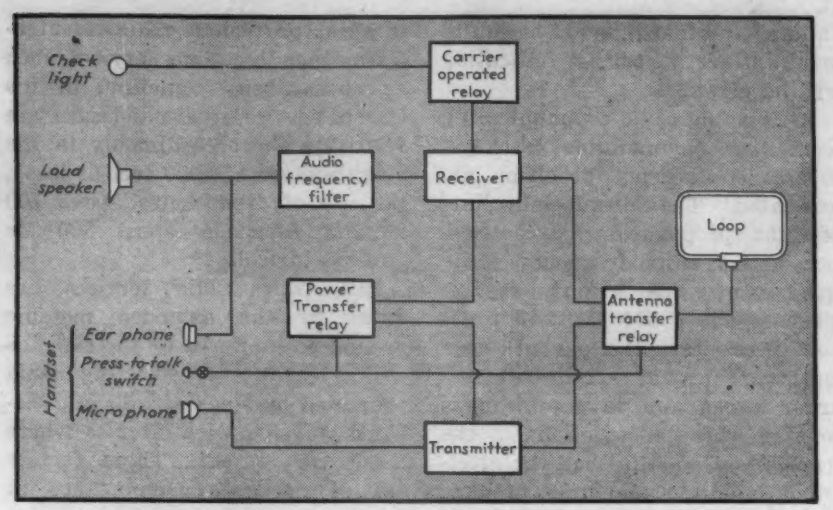


FIG. 6—Block diagram showing units employed on a locomotive in an induction radio system

long distances on an interstate basis, and in some instances a single railway system will span half a continent.

Unlike most other high-frequency radio services, therefore, allocation of frequencies for railroad use cannot be made on a limited-area basis as is the case in the majority of municipal, county, or state police radio installations. Studies now being made by the Federal Communications Commission and other governmental agencies, the Radio Technical Planning Board, the Association of American Railroads, and other groups should result in an intelligent, long-range solution to the allocation problem.

It is likely that full consideration will be given to the possible use of frequencies above 300 Mc, where service assignments have not yet been made, since there is an apparent dearth of available frequencies below 300 Mc. As an aid in this direction, development programs are now being conducted by capable engineering groups to determine the service capabilities of railroad radio equipment operating at frequencies above 300 Mc as well as at lower frequencies.

A relatively large number of automatic repeater stations, plus multichannel operation, will probably be required for use in main line operations. The cost of such repeater equipment, while it may not be prohibitive, does present an economic problem of considerable importance from the railroad operator's point of view.

Rail Carrier Telephone Systems

In rail carrier or induction telephone systems, in which carrier signal energy is fed directly to the rails (and sometimes secondarily to wayside wires), current flow is through the rails, with return through ground as shown in Fig. 3. The concentrated induction field produced by the rail current is utilized in reception by means of pick-up coils, usually located in proximity to the track.

Rail carrier telephone communication systems are useful only within a short lateral distance of rail circuits. As appreciable radiation of radio wave energy does not occur, such systems do not require Federal licensing or frequency allocation. As signals are confined substantially to railroad property, a degree of privacy exists which is not ordinarily obtainable with space radio systems. Rail carrier telephone systems offer means for effecting transmission of signals over comparatively long distances, sometimes in excess of 100 miles between wayside stations and trains and over distances of 10 miles or

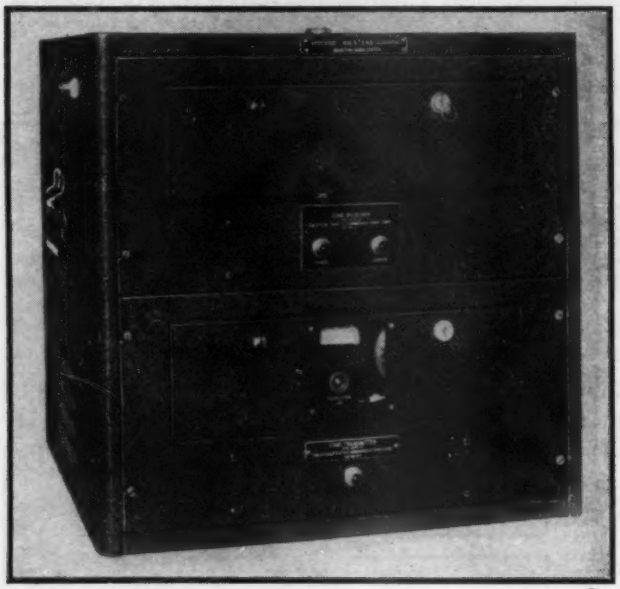


FIG. 7—Induction radio unit for fixed-station use, containing an f-m receiver, a zone transmitter, and a carrier-operated relay to provide automatic repeater functions. Power output is 10 watts

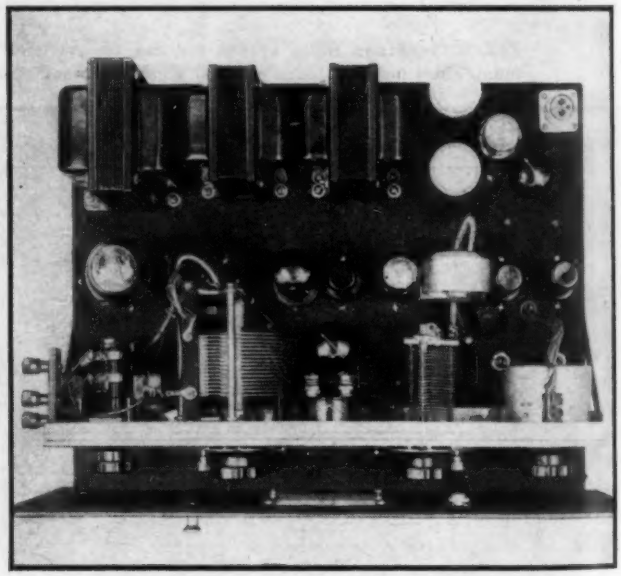


FIG. 8—Top view of the chassis of the f-m transmitter employed in the induction radio unit of Fig. 7. Tuning controls and other adjustments are behind a locked panel having a window for the meter at the center

more between trains, with relative absence of "dead spots" at bridges, tunnels, and other obstructions to normal space radio propagation.

Representative rail carrier telephone equipment now installed and in operation, such as that employed in a train communication system developed by the Union Switch and Signal Company,[3] ordinarily employs the upper side band of a relatively low-frequency carrier, such as 5700 cycles. Although frequencies below 10 kc are employed in rail carrier equipment now in operation on railroad systems, it is understood that frequencies as high as 250 kc and above may be utilized.

Carrier signal energy is supplied to the rails by direct metallic connection between the output circuit of the transmitter and the rails, usually by means of a connection from the output transformer to the insulated trucks of the locomotive or caboose. Signals normally are received on mobile units by inductive pick-up from the rails. At fixed stations, carrier signal energy ordinarily is applied between a wire line and a track as ground connection, although in some instances it is understood that signals are applied between tracks.

In rail carrier telephone installations now in service, mobile transmitting equipment with primary power input rating of approximately 500 watts is employed, with four 6L6 tubes in parallel push-pull connection in the power amplifier stage of the transmitter. Signal energy is applied to rail circuits by conductive connection between the output transformer of the transmitter and the rails, usually through the wheels of an insulated truck of the vehicle as indicated in Fig. 4.

The output transformer of the mobile transmitter is connected to a loop of one-inch copper pipe, extending from the insulated truck at one end of the vehicle through the secondary of the output transformer (with which a tuning capacitor is associated) to the truck at the other end of the vehicle, with the loop completed through the running rails between the wheels to which connections are made. The voltage drop across the impedance presented by the running rails between the wheels is the transmitting rail voltage, this voltage being produced along both rails in parallel.

Protective Checks on Rail Carrier Systems

Signal pick-up in mobile units is accomplished ordinarily by means of coils located beneath the mobile units and in proximity to the rails. The signal is then amplified and demodulated, with subsequent audio amplification after filtering and peak-limiting, for operation of the cab loudspeaker.

An indicating light is provided on a control box associated with the mobile transmitter and receiver, to serve as a check on emission of a modulated carrier. This light flickers with modulation of the carrier, thereby indicating to the user that an effective modulated carrier signal is being transmitted to the rail circuit. A signal selector unit may also be connected with the receiver to control the operation of a bell during calling operations, in which a 1050-cycle tone signal is impressed on the carrier at the station where the call originates. The same selector unit may also be used to control the operation of red and green cab signals. In this procedure, the green, or "proceed," light is energized as long as the 1050-cycle "calling" signal is being received, while the loudspeaker is disconnected. When the tone signal is terminated, the red, or "stop" light is energized, the bell is operated, and the loudspeaker is connected for speech reception. The "proceed" indication is thus given in accordance with the normally closed-circuit principle utilized in other forms of railway signaling.

The range of a rail carrier system is extended considerably when wire lines run parallel to main-line trackage, due to inductive coupling between the rails and the lines.

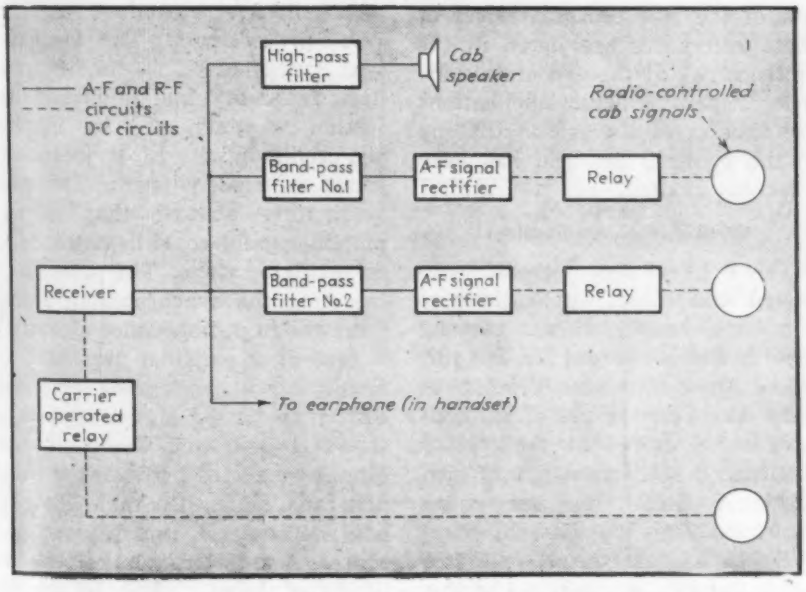


FIG. 9—Block diagram showing a-f signal selector units used in providing one form of automatic cab signal control.. Operation invalues reception of tone signals of predetermined frequencies, each related to a given traffic control signal. Voice signals may be received concurrently without interfering with control functions

Disadvantages of Rail Carrier Telephone Systems

Rail carrier or induction telephone systems, in which signal energy is impressed primarily on the rails, require good electric connections or bonding between the rails, which, in some instances, may entail considerable expense. As rail circuits rapidly attenuate carrier signal energy, transmitting equipment is of relatively large power-output rating and size as compared with space radio apparatus. Installation of rail carrier telephone equipment now in operation on some railways also requires the insulation of trucks of both the locomotive and the caboose from the body. If a locomotive is derailed, or in case of actual rail

(*Continued on page* 262)

Synchronized Oscillators as F-M Receiver Limiters

An oscillator stage following the i-f amplifier and synchronized to a subharmonic of the i-f signal gives voltage gain, adjacent-channel selectivity, quieting sensitivity, and good amplitude-limiting action. Synchronizing voltage can be injected in several ways

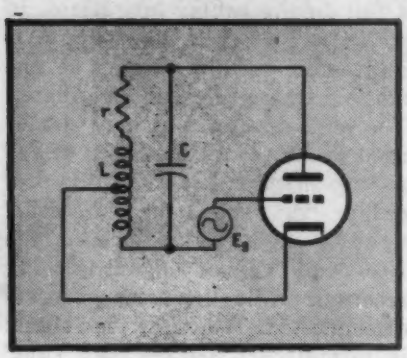


FIG. 1—Impedanceless generator in series with grid injects a synchronizing signal into a simplified Hartley oscillator

IN prewar f-m receivers the only nonlinear element was the amplitude limiter. Distortionless amplification of an f-m signal is independent, within limits, of the amplitude characteristic of the r-f and i-f amplifiers. Accordingly, it was thought that some of the nonlinear but extremely sensitive amplifiers used in the early days and long abandoned for a-m reception might prove useful as limiters in f-m receivers.

Following this line, the Zenith Laboratories in 1941 started a study of the possible advantages of synchronized oscillators in f-m reception. As used in an f-m receiver, the application comprises an oscillator stage following the i-f amplifier, with the oscillator frequency synchronized to the frequency of the i-f signal, or to a subharmonic of it. Thus, if frequency of the i-f signal deviates over 150 kc with a center frequency of 8.3 Mc, the synchronized oscillator may operate over the same range, or at a subharmonic such as 4.15 Mc, with a deviation of 75 kc. The practical application of subharmonic synchronization for frequency division is well known.[1]

Because of the priority of military work, research and development of this type f-m receiver have been on a limited scale. Unconventional ways have been found for using a synchronized oscillator to advantage, but these developments will have to wait for publication until practical application can be realized.

Interest in the phenomena exhibited by synchronized oscillators goes back to the early days of vacuum tubes and references are extensive. Several hundred papers, largely of a theoretical nature, have been written on the behavior of oscillators. Of these, a substantial fraction have dealt with synchronization and frequency division. A few of the best representatives of these references are listed in the bibliography at the end of this article. Papers on actual applications are scarce, for the reason that up to the present, the field has been relatively limited.

Some Actual Applications

There have been several suggested and actual applications to f-m receiver technique. Among these is British Patent No. 163,462, issued to Eccles and Vincent in 1920. It covers the use of an oscillator synchronized at the carrier frequency for the reception of narrow-band f-m, code and phone transmissions. The inherent selectivity of a synchronized oscillator seems to have been realized at this early date. Some work was also done about this time by H. G. Moller[7], who used a synchronized oscillator for f-m code reception.

The idea then seems to have languished until the middle thirties. In 1935, Armstrong[8] obtained a patent on the use of a synchronized oscillator at the intermediate frequency in an f-m receiver, with a limiter following the oscillator to remove amplitude variations. In 1938, the Japanese[9] described the use of a synchronized oscillator to separate the f-m component from a signal which contained both frequency and amplitude modulation. Their oscillator was adjusted so that it acted simultaneously as a fair amplitude limiter. Synchronization on a subharmonic of the received signal was tried, but unfavorable results were obtained.

In 1940 two Russian workers, Kisselgof and Knazev[10], suggested and built a synchronized amplifier for f-m receivers. The oscillator was synchronized at the intermediate frequency, and amplitude limitation was achieved by loading the oscillator with a pair of shunt-connected diode clippers. These investigators showed that normal amplifier gains could be obtained in an oscillator stage. The problem of injecting the synchronizing signal from the high-impedance circuit of a preceding amplifier was met by employing a pentagrid tube, the 6L7, with the i-f signal applied to the first grid and the oscillation circuit connected between the third grid and plate. By thus allowing only electron coupling between the source of injected voltage and the oscillator circuit they minimized interaction between the two circuits and thereby eliminated a major feedback problem.

By C. W. CARNAHAN and HENRY P. KALMUS

Zenith Radio Corp.
Chicago, Ill.

Practically all the references on the synchronized oscillator are theoretical in nature, and highly mathematical, due to the non-linear differential equations involved. While a simplified explanation may lack rigor, at least it has the advantage of presenting a physical picture of the mechanism of synchronization for both fundamental and subharmonic operation.

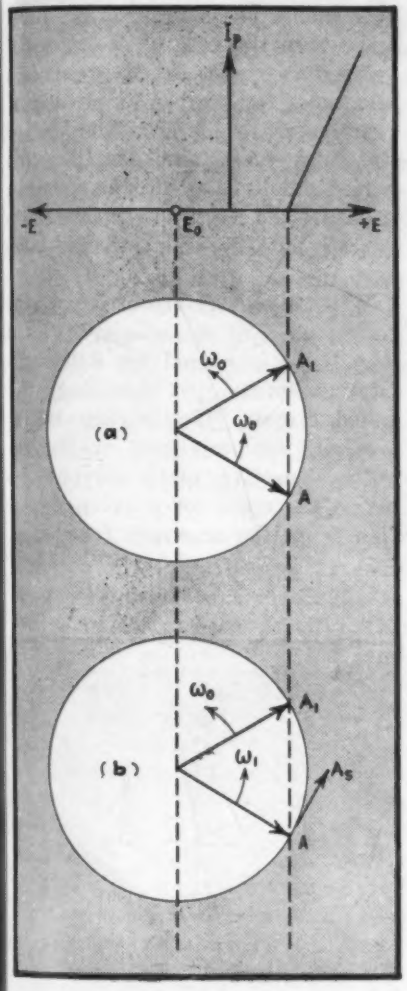


FIG. 2—Plate current of oscillator in Fig. 1 is a function of instantaneous voltage across tank circuit, which appears as the projection of vector *A*. For a free-running oscillator, (a) angular velocity is assumed constant. In (b), angular velocity of the synchronizing signal is greater and A_2 is the tank-voltage component due to synchronizing voltage

This analysis is based on a consideration of the actions occurring over one cycle of a synchronized oscillator. Such a treatment has been published recently for a free-running Hartley oscillator[11]. Referring to Fig. 1, consider a simplified Hartley oscillator with the tank circuit connected between plate and grid, and with the synchronizing signal injected by an impedanceless generator in series with the grid lead.

Theory of the Synchronized Oscillator

Figure 2(a) shows the plate current of the tube as a function of the instantaneous voltage across the tank circuit. The oscillator is assumed to operate class C without plate-current saturation. Figure 2(a) shows instantaneous oscillator voltage as the projection of a vector A of variable length, rotating in a counter-clockwise direction. For a free-running oscillator, i.e., $E_s = 0$, the angular velocity of this vector may be assumed constant over the cycle. From A_1 to A, the g_m of the tube is zero, the damping factor of the oscillation is positive, and the vector amplitude decreases exponentially.

From A to A_1, the amplitude must increase exponentially to its original value if oscillation amplitude is to remain stable. During this amplification period, when the tube is conducting, the damping factor is negative. The condition for stability in a free-running oscillator is that the loss in amplitude during the cut-off period, when the tube is not conducting, must be just equal to the gain in amplitude during the amplification period.

We have assumed that for a free-running oscillator the angular velocity of the amplitude vector is constant, and equal to the resonant

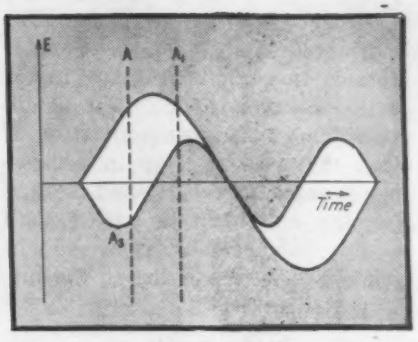


FIG. 3—Phase relations between oscillation and synchronizing voltage when the latter is of twice the former's frequency. Time lapse here represents the amplification period of the tube, during which the effect is that of a synchronizing wave of identical frequency but double amplitude

angular velocity of the tuned circuit. Actually, angular velocity during the amplification period will differ from this, because of the changed circuit conditions during this period, with the result that the *average* angular velocity of the amplitude vector of a free-running oscillator over one cycle will, in general, not agree exactly with the resonant angular velocity of the tank circuit.

The possibility of a change in angular velocity during the amplification period gives the clue to what occurs during synchronization. For if E_s is not zero, and has an angular velocity not equal to that of the free-running oscillator, stable synchronization means that the average angular velocity of the oscillation amplitude vector must change until it is equal to that of the injected signal.

During the cut-off period, synchronizing voltage E_s can have no effect on the oscillation vector, the angular velocity of which during this period is, say, ω_0, the resonant angular velocity of the tuned circuit. During the amplification period, however, E_s causes a component of plate current which may change the phase angle of the oscillation vector. Thus the angular velocity of the oscillation vector during the amplification period may be decreased or increased, depending on whether the phase of the plate current produced by E_s is lagging or leading the phase of the free-running oscillation current at the start of the amplification period.

If the angular velocity of E_s is

greater or less than ω_o, synchronization occurs only when the A vector rotates through 2π radians in exactly one cycle of E_s. The condition for stable synchronization is that the gain or loss in relative phase angle between A and E, during the amplification period shall exactly balance the loss or gain in relative phase angle during the cut-off period.

Vector Relations

In Fig. 2(b), are shown the vector relations existing when the angular velocity of the synchronizing signal is greater than ω_o, the free-running angular velocity. Here A, is the component of the tank voltage due to the synchronizing voltage E_s. This component is added in quadrature with the oscillation vector during the amplification period, so the angular velocity, ω_1, of the resultant is increased during this period. If ω_s is the angular velocity of the synchronizing signal, the average value of angular velocity of the resultant over a complete cycle must be equal to ω_s, for stable synchronization.

For a given difference between ω_o and ω_s, the angular velocity of E_s, the phase angle between E, and A at the start of the amplification period will be 90 deg for the minimum amplitude of E, required for synchronization. If the magnitude of E, is less than this critical value, the gain in phase during the amplification period will not balance the loss in phase during the cut-off period, and the effect of E, during the next conductive period will be reduced due to the discrepancy in correct phasing at the start. Thus the phase conditions never stabilize, and no synchronization exists.

If the magnitude of E, is greater than that required at optimum phasing, the gain in phase during the amplification period will be greater than required, and the phase at the start of the next amplification period will be less than 90 deg, thus reducing gain in this period. This process will continue until the relative phase at the start of the amplification period is reduced to a value which remains stable with the given magnitude of E_s.

The phenomenon of stable synchronization is thus due to the fact

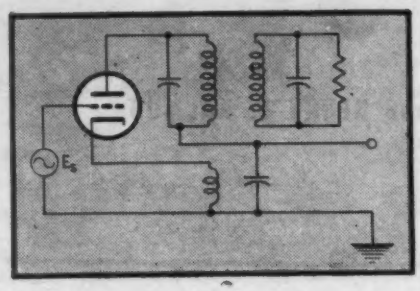


FIG. 4—Addition of a tuned secondary to the tank-circuit inductance increases synchronization sensitivity by reducing phase-angle variation of the primary impedance

that the oscillation vector can slip in relation to the synchronizing vector until stable phase and amplitude conditions are reached. If E, is variable in frequency, but always of sufficient amplitude, the oscillator will adjust itself almost instantaneously to every change in frequency of E_s.

Synchronization with an injected signal whose frequency is a multiple of the free-running frequency can be explained in a similar manner. Figure 3 shows the phase relations which might exist during the amplification period and between the oscillation voltage and a synchronizing voltage of twice the frequency. During the active period the double-frequency synchronizing wave is practically equivalent to a synchronizing wave with the frequency of the oscillator but twice the amplitude of the double-frequency wave. It is clear that if the amplification period extended beyond the boundaries marked in Fig. 3, the effect of the injected voltage at double frequency would be to decrease the desired change in oscillation vector phase, since the added portions would produce a reactance change in the opposite direction.

For subharmonic operation, the fraction of the oscillator cycle comprising the amplification period should be limited to a half cycle (or an odd multiple of a half cycle) of the synchronizing voltage.

Sensitivity of Synchronization

While the method of injecting synchronizing voltage shown in Fig. 1 cannot generally be realized in a practical f-m receiver, it can be used to illustrate the factors affecting synchronization sensitivity of the amplifier-limiter in practical circuits, since the same general principles hold for all.

Synchronization sensitivity may be defined roughly as the amplitude of the injected voltage required to synchronize the oscillator over a given frequency range of the synchronizing voltage, for a given oscillator frequency and amplitude.

Since the synchronization process is essentially that of adding a reactive component of current during a fraction of the oscillator cycle in order to slow down or speed up the angular velocity of the oscillation vector during this period, the action is similar to that of a frequency modulator of the reactance tube type. Factors affecting sensitivity are the same in both cases.

The L/C ratio of the tank circuit should be as high as possible, since then the reactive voltage developed across the tuned circuit is a maximum for a given amplitude of reactive plate current. The g_m of the tube during the amplification period should be as high as possible, to secure the required reactive plate current with the least injected voltage.

With the single-circuit oscillator shown in Fig. 1, sensitivity can usually be increased for low oscillator voltages by damping the tuned circuit. If damping is increased, the amplitude of the required reactive plate current remains the same for a given deviation from the resonant frequency,

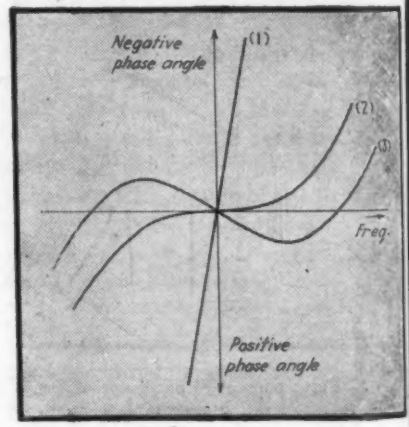


FIG. 5—Phase characteristics of primary impedance in Fig. 4 for a single circuit (1), two circuits critically coupled (2) and two circuits over-critically coupled (3). In curve (3), synchronization sensitivity in the center is largely lost

since the decrease in impedance of the tuned circuit is balanced by a decrease in the phase angle of the impedance. However, the g_m of the tube during the amplification period must be increased to maintain the same oscillator voltage, and hence the required synchronizing voltage on the grid of the tube is decreased. For optimum adjustment, damp the tuned circuit until, for a desired oscillator voltage, the plate current and the g_m of the tube are as high as possible.

In a single-circuit oscillator the required reactive current varies linearly with frequency deviation for a small range on either side of resonance, since it varies with the sine of the phase angle of the tuned circuit impedance. This phase-angle variation may be reduced by a large factor over a small range, and synchronization sensitivity correspondingly increased, by adding a tuned secondary to the tank circuit inductance, as shown in Fig. 4. If circuit Q factors and coupling are adjusted to give a band-pass characteristic over the desired frequency range, the phase angle variation of the primary impedance can be easily reduced by a factor of five or more, with a corresponding increase in the synchronization sensitivity.

Figure 5 shows the phase characteristics of the primary impedance for (1) a single circuit, (2) two circuits critically coupled, and (3) two circuits over-critically coupled. Even a moderate degree of coupling will provide considerable improvement of the sensitivity. This increase in sensitivity with a band-pass tank circuit was first noted by Sterky.[12] If the two circuits are over-critically coupled, giving the phase characteristic (3) of Fig. 5, the free-running frequency of the oscillator tends to rest on either side of the double bend in the characteristic, and synchronization sensitivity to a signal in the center is largely lost. This condition may also occur unintentionally through regenerative coupling to a preceding high-Q i-f circuit, and is to be avoided at all costs.

Difficulties with Subharmonics

All the factors discussed above, namely High L/C ratio, high g_m, and two-mesh tank circuits, which make for high synchronization sensitivity at the fundamental, also hold for synchronization at a subharmonic of the injected voltage. This is because, as discussed above, the action of the injected signal at a higher frequency than the oscillator, over a limited period of amplification, is exactly analogous to the action of a signal at the same frequency as the oscillator. There is, however, some loss in sensitivity over operation at the fundamental, due to the restriction of the amplification period, and the only justification for subharmonic operation is that it avoids the practical difficulties of feeding an oscillator from a high-impedance source, and minimizes difficulties in oscillator alignment due to overall regeneration.

Some of the loss in sensitivity entailed in subharmonic operation can be recovered by a proper adjustment of bias on the oscillator, since this determines the length of the amplification period. In general, however, fixed bias on the oscillator grid makes it difficult to start at the desired level of 5 to 10 volts, and not much latitude exists in bias voltage.

Suppression of Subharmonic Oscillations

An unpleasant feature which is associated with high sensitivity for subharmonic operation is the long-known fact that oscillations at the subharmonic frequency are suppressed if the injected signal rises to the same order of magnitude as the oscillator voltage. This is sometimes not recognized at first if a demodulated signal is viewed on an oscilloscope.

Distortion caused by suppression of the subharmonic at the center of the band then has a similar appearance to distortion caused by insufficient synchronizing signal and the consequent loss of synchronization over part of the modulation cycle. The effect appears to be due to upper bend saturation in the tube characteristic, so that too much injected voltage lowers the effective g_m of the tube to the point where the lower-frequency oscillations can no longer be sustained. While this effect is analogous to i-f overloading in an a-m receiver, the resulting audio distortion is much worse, and cannot be tolerated.

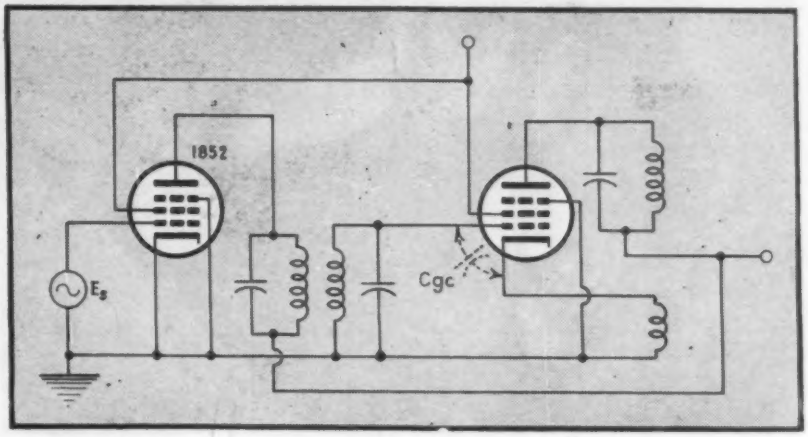


FIG. 6—Typical synchronized-oscillator circuit having synchronizing voltage developed in the grid circuit of the type 1852 tube while oscillation is maintained by a cathode tickler winding

If minimum synchronizing voltage, delivered by the i-f amplifier, is of the order of a volt, suppression of the subharmonic oscillation by stronger signals can be satisfactorily overcome with a complete automatic gain-control circuit deriving voltage from rectification in the last i-f grid circuit before the limiter. If, however, full advantage is taken of the gain in a synchronized oscillator, the required minimum synchronizing voltage will be much less than one volt, and generally there will not be enough gain in the i-f amplifier to provide satisfactory gain control. Fortunately, special circuit means exist that will not suppress the oscillation until the voltage on the last i-f amplifier is high enough to cause this stage

(*Continued on page* 332)

Carrier Communication

Orders go to crane operators by wireless means in this installation and all transmission is cleared through a central desk. Inherent disadvantages of telephone systems are overcome while control and coordination are improved

Experimental model of special-design receiver for carrier-current signal reception fits into the corner of a crane cab at plant No. 2 of GM's Fisher Cleveland Aircraft Div. At the controls is R. B. Jones, who had charge of construction and testing on the installation

By M. L. SNEDEKER *Radio Section General Foreman, Fisher Cleveland Aircraft Div., General Motors Corp., Cleveland, Ohio*

DIRECT audio communication with crane operators has been provided in many industrial plants by telephone. The utility of such systems has often suffered from delays in transmission of orders because of a busy line and confusion because several individuals might call the cabman concerning the same job of lift.

Clearing of all instructions to the crane operators through one central desk is highly desirable since it enables the operations foreman always to know just where each of the several cabs is operating. There are also occasions when two cabs must operate from the same bridge for lifting heavy pieces. In addition to requiring no special conductors, a carrier-communication system held the promise of greater flexibility than telephone service.

Power Distribution System

As is usually the case, working out the idea required considerably more effort than its formulation did. An investigation was first made of the power distribution system of the plant. Several interesting points came to light—chief among which was the fact that it consisted, for the most part, of three-conductor sheathed-in-lead cable having a very high capacitance to ground.

From the 132-kv high-line, two banks of transformers feed two 4800-volt busses to the various sub-stations throughout the plant. In each sub-station is located a 4800-440-volt step-down transformer connected delta-delta.

Line Coupling Unit

An attempt was made to feed the 160 kc carrier frequency into the 440-volt service mains. As expected, there was little or no success—variations in the power load were very great, with the result that transmitter loading was also changed.

The r-f energy was next fed into the 4800-volt side of one of the sub-stations through a 0.001 μf blocking capacitor. Considerable difficulty was experienced in coupling the transmitter output to the power mains; impedance of the power system was such that satisfactory loading of the transmitter could not be achieved. A number of schemes were tried, the final result being the tapped vario-coupler shown in Fig. 1.

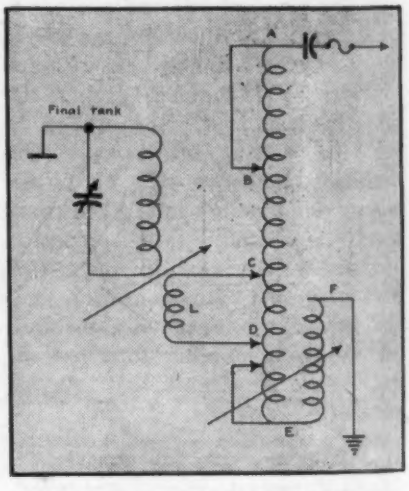


FIG. 1—Line coupling unit consists of tapped vario-coupler with coarse impedance-matching adjustment by taps

to Crane Cabs

Between *C* and *D* the winding is tapped every turn: this allows the impedance of the link *L* to be closely matched. The winding between *A* and *B* is tapped every seventh turn. This provides a coarse adjustment of inductance while fine adjustment is made with the rotor *EF*. The entire variocoupler *AE* consists of 272 turns of No. 16 wire on a four-inch diameter form.

In the rotor are 34 turns of No. 16 wire on a three-inch diameter form. Inductance is 0.07 mh. The link *L* consists of 12 turns of No. 14 enameled wire, wound on a 3½-in. diameter form. This is coupled concentrically to the final tank circuit of the transmitter. With this arrangement it is possible to load the transmitter to any desired amount, and power-load variations seem to have no effect.

Using this set-up with an r-f power of approximately 50 watts, excellent coverage throughout the plant was achieved, even though some of the runs through the lead-sheathed 4800-volt cables were several hundred feet in length. Carrier-frequency traps in the load lines adjacent to the feed point were not used since there was satisfactory signal strength without them.

Comprising a 6F6 electron-coupled oscillator operating at 160 kc, a 6V6 buffer and two 807's in parallel as the final amplifier, the transmitter circuit is quite conventional.

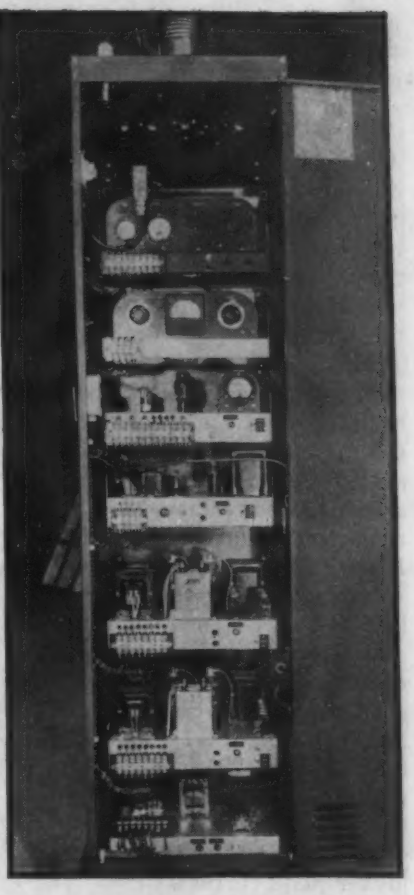
Transmitter for Minimum Maintenance

Push-pull 6L6's are used in the modulator unit. While the circuit of the transmitter is more or less standard, there are two special features. Every component of the transmitter, and particularly of the power supply units, was designed to operate considerably below its maximum rating since the system is in operation 24 hours a day. This over-design has paid dividends by providing almost zero maintenance.

The entire transmitter is housed in a cabinet with a thermostatically controlled blower set to operate when the ambient temperature exceeds 130 deg. F. A block diagram is shown in Fig. 2.

Special Receivers Required

Initial tests, made with a commercial receiver in a crane cab, indicated that special receiving equipment would be necessary. The electrical noise level in the plant was so high that ordinary noise suppression circuits were useless. It was evident therefore that a signal of considerable strength would have to be available at the receiver and also that a highly effective squelch circuit must be employed.



Cabinet of carrier-current transmitter contains, from top to bottom, line matching unit, final amplifier, oscillator-buffer, modulator, local speech amplifier, modulator power supply, final power supply, and control elements. Thermostatically-controlled ventilating blower has intake through elbow on top

With these requirements in mind, an r-f power of 50 watts was decided upon, and a great deal of experimenting was done with all sorts of noise-reducing circuits.

The receiver used in the crane installations was designed by E. T. Rosenberg and is diagrammed in Fig. 3. Of special interest is the squelch circuit.

Employing a straightforward t-r-f circuit, the receiver uses three 6SK7 tubes as r-f amplifiers, a 6SQ7 tube as diode detector and first audio amplifier, a 6F6 as power amplifier, a 6SJ7 in a squelch or carrier-operated noise-suppressor circuit, and a type 80 rectifier. Ordinary 175-kc i-f transformers tuned to approximately 160 kc are utilized as interstage transformers T_1 to T_4.

Bias for the first two r-f amplifiers is obtained through a 500-ohm resistor in each cathode, both re-

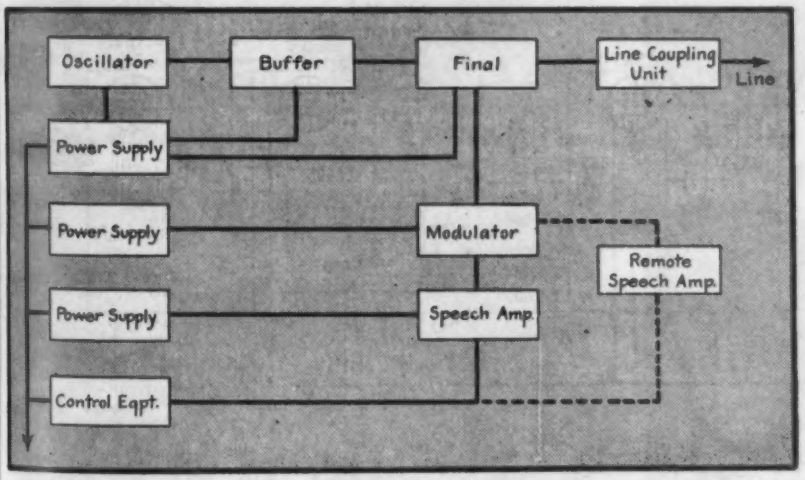


FIG. 2—Block diagram relates functions of units in transmitter rack illustrated. Remote speech-amplifier is located at the dispatcher's desk, with duplicate in cabinet for test purposes

sistors being run to ground through a common 25,000-ohm sensitivity control. In ordinary operation this control is left in the extreme counter-clockwise position, of maximum resistance. The cathodes are then approximately 13 to 15 volts above ground. The third r-f amplifier has a cathode bias of 2.5 to 3 volts, obtained by means of a 500-ohm resistor from cathode to ground.

Screen voltage for the r-f amplifiers and the squelch tube is obtained from a voltage divider consisting of a 15,000-ohm resistor and a 10,000-ohm resistor in series across the power supply. This arrangement supplies approximately 100 volts to the screens.

Incorporated in the plate supply lead to each r-f amplifier is a filter consisting of a series 10,000-ohm resistor and a 0.05-μf by-pass capacitor. Voltage, measured at the plates of the 6SK7 tubes, will be from 225 to 285 volts, with the voltage at the third r-f tube plate being somewhat lower than the others, due to the lower bias and higher plate current.

The type 6SQ7 tube is connected as a conventional diode detector and audio amplifier; the diodes being tied together to form a half-wave rectifier. Rectified r-f voltage appears across the load resistors, 50,000-ohms and 250,000-ohms connected in series from the cathode to the low side of the r-f transformer secondary.

Audio voltage is picked off at the junction of the resistors and applied across the 250,000-ohm volume control through a 0.004-μf capacitor. The arm of the potentiometer goes directly to the grid of the triode, which is resistance coupled to the 6F6 output tube. Bias for the 6SQ7 is obtained by means of a 5,000-ohm resistor from cathode to ground. The 10,000-ohm squelch control is in parallel with this resistor. Since the cathode of the 6SJ7 squelch tube is tied to that of the 6SQ7, the total plate current of both tubes flows through this parallel combination.

Squelch Circuit

Operation of the squelch circuit is as follows: The control grid of the 6SJ7 is tied through a 0.5 megohm filter-resistor to the low side of the diode load resistor. With no signal, there is no diode current and no voltage drop across the diode load resistor. Since the 6SQ7 and 6SJ7 cathodes are connected together, there is no bias on the 6SJ7 tube, which, therefore draws 6 or 7 ma of plate current. This causes a large drop across the paralleled 5,000-ohm resistor and 10,000-ohm squelch control, biasing the 6SQ7 beyond cutoff and rendering the receiver inoperative.

When a carrier is received, a d-c voltage appears across the diode load resistor and biases the 6SJ7 to cutoff. The only current now flowing through the paralleled bias resistor and squelch control is the plate current of the 6SQ7, the bias of which is now at the correct operating value, and the receiver functions normally. Obviously, the receiver should never be operated with the squelch in the maximum clockwise, or minimum resistance, position as this will remove all bias from the 6SQ7 and cause excessive current to flow. Bias on the 6SQ7, without signal, is 15 to 17 volts; with signal, 1.5 to 2 volts.

Voltage at the plate of the 6SQ7 is approximately 200 to 250 volts. Voltage at the plate of the 6SJ7 is 285 to 300 volts, the same as that at the screen of the 6F6 since both are connected directly to the output of the plate supply filter. Plate voltage on the 6F6 is 275 to 290 volts and grid bias, about 17 volts, is obtained by means of a 500-ohm resistor from cathode to ground.

Designed for 110-volt 60-cycle operation, the receiver power supply consists of an ordinary, commercial power transformer, full wave rectifier, and single-section capacitor input filter. For operating the receiver from the 440-volt 3-phase power source in the crane cabs, the primary of the power transformer is connected in series with a bank of four 50-watt, 115-volt, rough-service lamps across one phase. A separate fuse and switch-box is provided for the receiver which is independent of the interlock and manual safety switches in the crane cab. The antenna lead from the receiver is connected to all three phases

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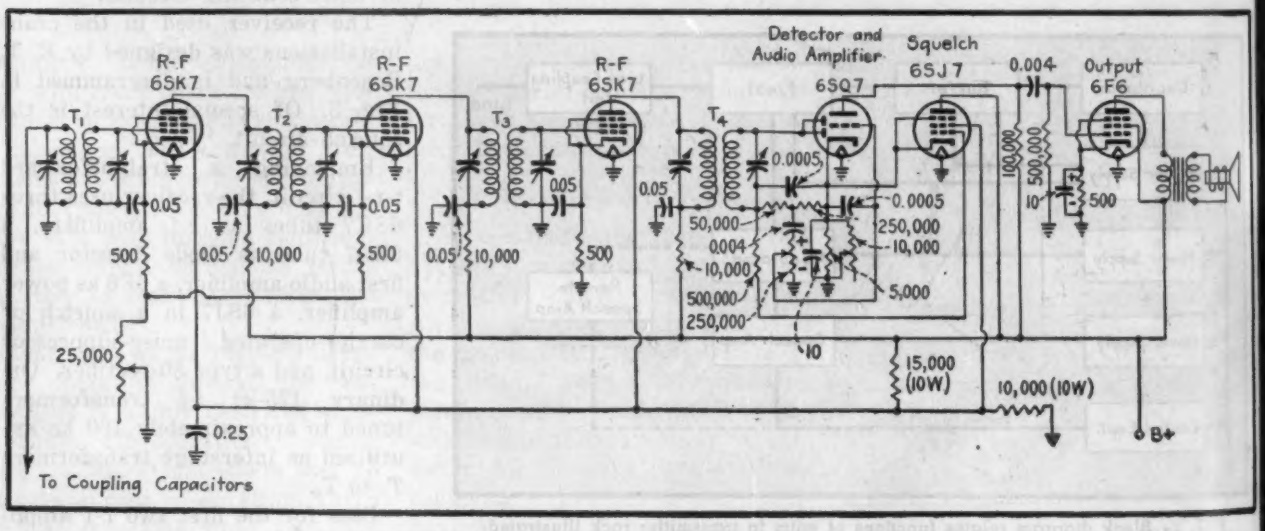
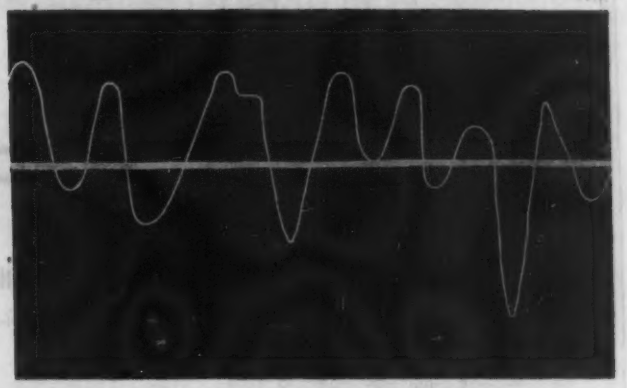
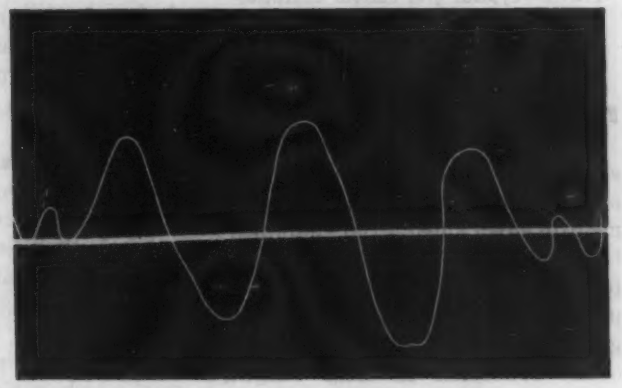


FIG. 3—Schematic diagram gives details of special receiver designed and built for carrier-current crane communication. Controls include sensitivity, volume, and squelch

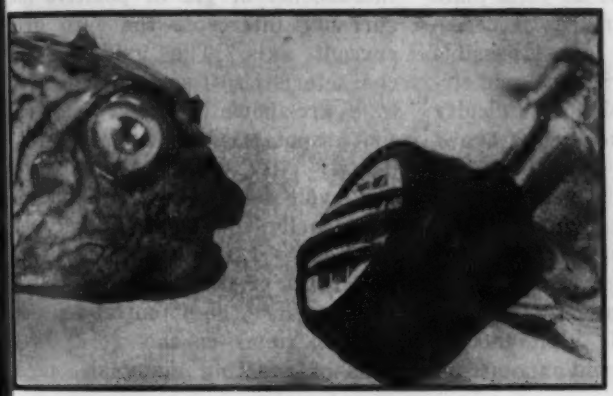
FISH TALK

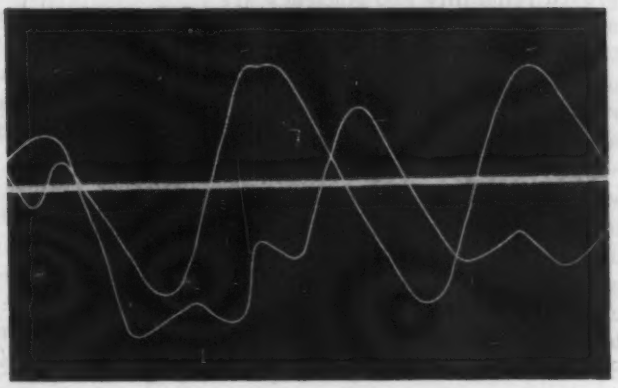


Working with the set-up above, Dr. Christopher Coates of the New York Zoological Society Aquarium has classified fish moods and their corresponding audible manifestations. Trace at right represents the sounds of feeding goldfish

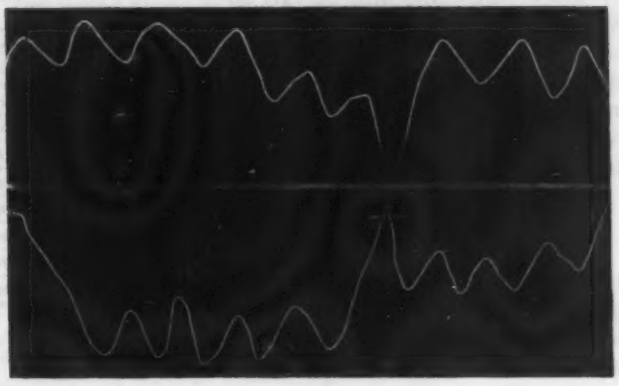


Osculation at left and corresponding oscillation at right, above, characterize an amorous pair of Malayan gouramies. Many fish make sounds by grinding their teeth, while others blow air from swim bladders to make croaking noises





No political implications, just an angry boxfish, above, expressing indignation after having been jabbed with a pencil. Grunts of annoyance form agitated, uneven curves. Happy catfish, below, produces purring sound pictured at the right



28-Volt Operation of Receiving Tubes

By C. R. HAMMOND, E. KOHLER and W. J. LATTIN

Ken-Rad Tube & Lamp Corporation, Owensboro, Kentucky

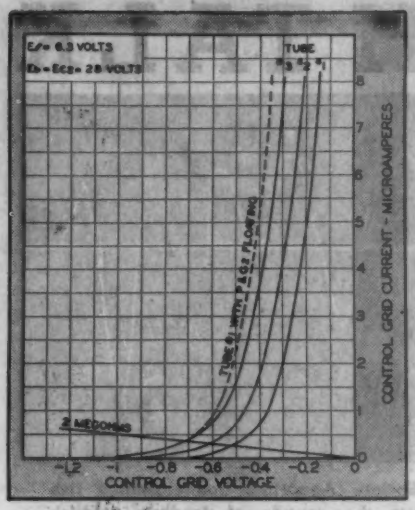


FIG. 1—Typical grid current characteristics of type 9003 pentode in contact potential region

THE APPLICATION of receiving tubes at plate and screen voltages of 28 volts enables the designer of aircraft radio and related equipment to effect substantial simplifications. The direct use of the aircraft primary battery for the B supply permits elimination of high-voltage generating components with consequent reduction in size, weight, cost, maintenance, and power requirements of the equipment. Improved reliability and efficiency are also obtained.

Heretofore there has been a lack of published data and performance ratings covering operation of available tube types from a 28-volt B supply. This paper attempts to provide this data for typical operation of standard r-f pentodes, triodes, and voltage amplifier types. Single-ended 12-volt metal types were chosen mainly because they have been the accepted standard of the Services and of the majority of leading aircraft radio manufacturers. Miniature tube types are included because they will exhibit advantages in vhf equipment. Data on several GT double-triode types are given, since it is thought they may find application as phase inverters, multivibrators, or oscillators.

Operating Problems at 28 Volts

Operation of electron tubes with plate and screen voltages obtained directly from the primary 28-volt aircraft battery offers a few difficulties which must be recognized in establishing design practices, equipment performance tolerances, and choice of tube types. These difficulties are principally:

1. Variation of grid contact potential between tubes of a given type.

2. Greater percentage variation of transconductance and other characteristics, for certain types (tube-to-tube) than is experienced with the same tubes at maximum voltage ratings.

3. The wide range of battery voltage (occurring in the aircraft) over which satisfactory tube performance must be obtained.

Tube operation at 28 volts plate and screen supply makes it necessary to employ the lowest possible bias. At zero bias with low grid circuit resistance, an obvious difficulty with grid current loading of tuned circuits arises. At low orders of fixed or cathode bias difficulty is experienced with many tubes of a large lot drawing grid current because the bias is not high enough to overcome the contact potential. If the bias is made high enough that no tubes draw grid current the average gain for all tubes is at an undesirable low level. A good compromise is to employ grid-leak bias which evens out the variations of gain from tube to tube. Tubes which tend to run high in grid contact potential also tend to run high in transconductance, and vice versa, so that tubes with high G_m will bias themselves back further than tubes with low G_m.

Effective Grid Bias

We define grid contact potential, as employed in this discussion only, to be that grid potential at which the grid current characteristic (in the absence of gas or positive ion current) intercepts the zero grid current axis. The grid current characteristics of several type 9003 tubes are shown in Fig. 1. The grid contact potential values are approximately −0.7 volt for tube 1 and −1.0 volt for tube 3. The values are usually found to lie between −0.2 and −1.2 volts for most vacuum tubes of the classes discussed herein. Since the potential depends on such items as the work functions of emitting materials, mean

TABLE I—CHARACTERISTICS OF R-F PENTODE AMPLIFIER TYPES WITH 28-VOLT B SUPPLY

TYPE	TRANS-CONDUCTANCE	PLATE RESISTANCE	PLATE CURRENT	SCREEN CURRENT	CUTOFF BIAS *
6AG5	1300 μ MHOS	OVER .1 MEG.	.40 MA	.10 MA	−2 V.
12SF7	1075 μ MHOS	OVER .4 MEG.	2.0 MA	.60 MA	−9 V.
12SG7	1325 μ MHOS	OVER .75 MEG.	.75 MA	.35 MA	−5 V.
12SH7	1200 μ MHOS	OVER 2 MEG.	.35 MA	.15 MA	−2 V.
12SJ7	1350 μ MHOS	OVER .75 MEG.	1.0 MA	.30 MA	−3 V.
12SK7	1350 μ MHOS	OVER .3 MEG.	2.0 MA	.60 MA	−10 V.
9001	1150 μ MHOS	OVER .7 MEG.	.65 MA	.30 MA	−3 V.
9003	1250 μ MHOS	OVER .3 MEG.	1.6 MA	.70 MA	−10 V.

* Cutoff bias for transconductance of 10 micromhos. Data in this table was obtained with rated heater voltage, plate and screen voltage of 28 volts and grid bias of zero volts through 2 megohms.

Performance of pentodes and triodes operated directly from an aircraft battery as B supply. Grid leak bias is recommended to minimize effects of grid contact potential and G_m variations. Tables show performance of RC-coupled amplifiers in 28-volt service

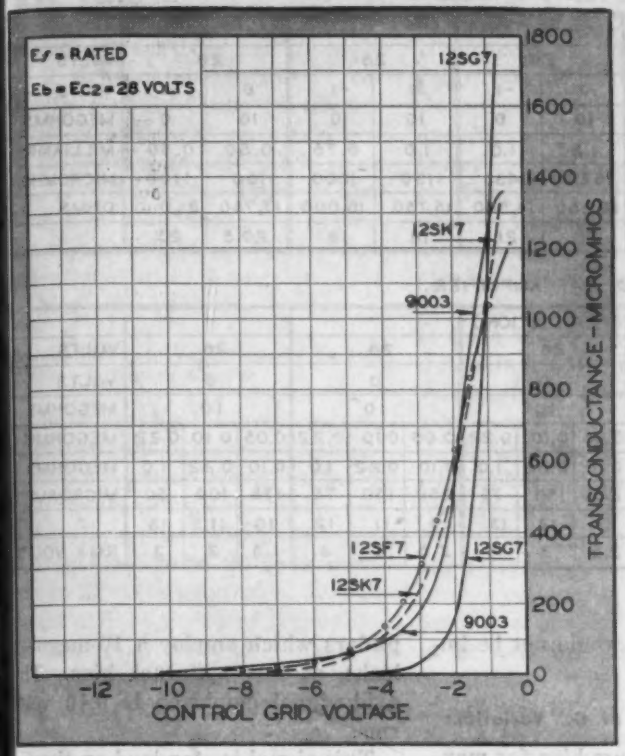


FIG. 2—Transconductance vs. control grid bias for remote cut-off pentodes

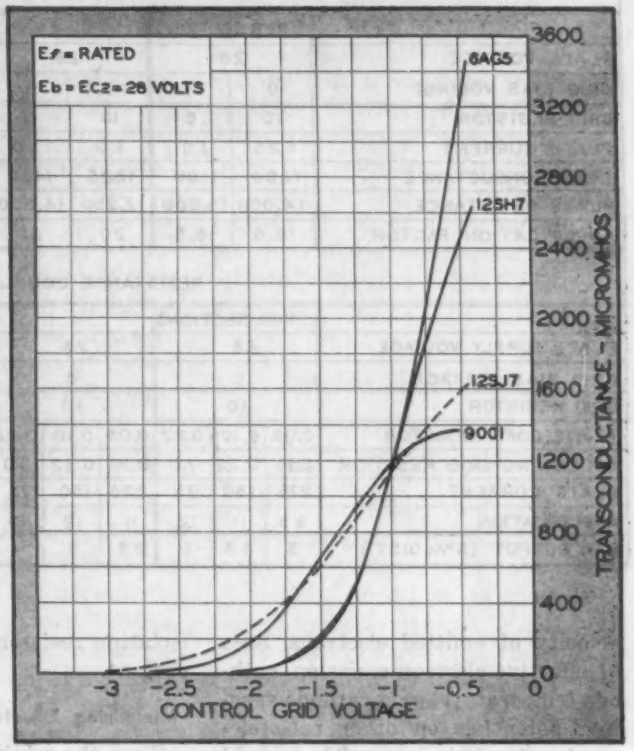


FIG. 3—Transconductance vs. control grid bias for sharp cut-off pentodes

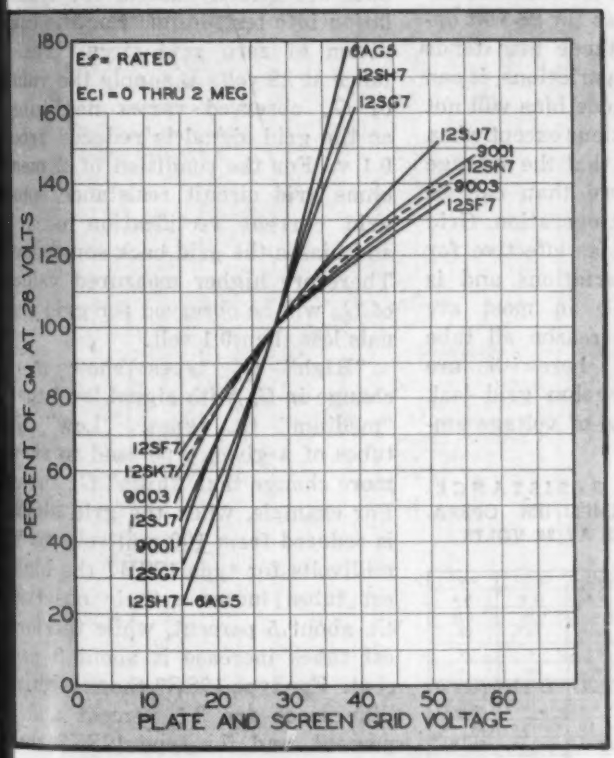


FIG. 4—Percentage variation of transconductance of r-f pentodes with B supply voltage

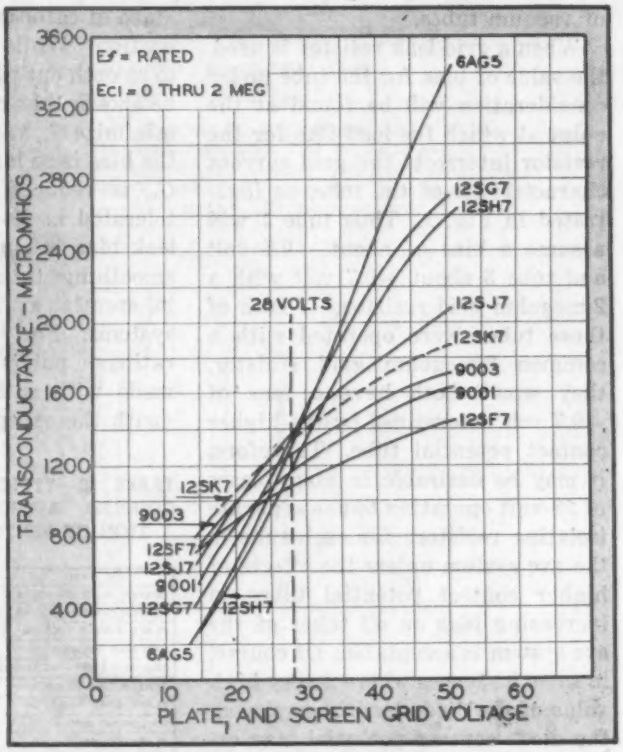


FIG. 5—Transconductance of r-f pentodes vs. B supply voltage, for eight different tube types

TABLE II—TYPICAL AUDIO AMPLIFIER OPERATION OF TRIODES AT 28 VOLTS

TUBE TYPE	12AH7GT		12J5GT		12SN7GT		12SR7		9002		
HEATER VOLTAGE	12.6		12.6		12.6		12.6		6.3		VOLTS
HEATER CURRENT	0.15		0.15		0.30		0.15		0.15		AMPS
TRANSFORMER OR CHOKE FED A-F AMPLIFIER											
	(PER SECTION)				(PER SECTION)						
PLATE VOLTAGE	28		28		28		28		28		VOLTS
GRID BIAS VOLTAGE	0	-1	0	-1	0	-1	0	-1	0	-1	VOLTS
GRID RESISTOR	10	0	10	0	10	0	10	0	10	0	MEGOHMS
PLATE CURRENT	1.25	1.0	1.2	1.0	1.2	1.0	1.0	0.75	0.50	0.50	MILLIAMPS
TRANSCONDUCTANCE	1200	1100	1625	1450	1625	1450	1150	1000	1150	1100	MICROMHOS
PLATE RESISTANCE	14,000	15,000	12,250	14,500	12,250	14,500	15,750	18,000	17,750	21,000	OHMS
AMPLIFICATION FACTOR	16.8	16.5	20	21	20	21	18	18	20.5	23	
RESISTANCE COUPLED A-F AMPLIFIER											
	(PER SECTION)				(PER SECTION)						
PLATE SUPPLY VOLTAGE	28		28		28		28		28		VOLTS
GRID BIAS VOLTAGE	0		0		0		0		0		VOLTS
GRID RESISTOR	10		10		10		10		10		MEGOHMS
PLATE LOAD RESISTOR	0.05	0.10	0.22	0.05	0.10	0.22	0.05	0.10	0.22	0.05	0.10	0.22	0.05	0.10	0.22	0.05	0.10	0.22	MEGOHMS
FOLLOWING GRID RESISTOR	0.10	0.22	1.0	0.10	0.22	1.0	0.10	0.22	1.0	0.10	0.22	1.0	0.10	0.22	1.0	0.10	0.22	1.0	MEGOHMS
PLATE CURRENT	275	150	75	225	150	75	225	150	75	250	150	75	175	100	50	175	100	50	MICROAMPS
AMPLIFICATION	9.5	11	12	11	12	13	11	12	13	9	11	12	10	11.5	13	10	11.5	13	
MAX OUTPUT (5% DIST)	3	3.5	5	2.5	3	4	2.5	3	4	2.5	3	4	1.5	2	3	1.5	2	3	RMS VOLTS

velocity of emitted electrons, area of effective electron emission, cathode temperature, grid-cathode spacing, potentials on other tube elements, etc., it is impossible to hold the value to that degree of uniformity achieved in the control of other parameters during the manufacture of vacuum tubes.

When a grid leak resistor is used, the value of bias for the tube under consideration will be found at the point at which the load line for the resistor intersects the grid current characteristic of the tube, as illustrated in Fig. 1. Thus tube 1 will assume a bias of about −0.5 volt and tube 3 about −0.7 volt with a 2-megohm grid resistor. If both of these tubes were operated with a common 2-megohm grid resistor, they would both have a bias of −0.7 volt determined by the higher contact potential tube. Therefore, it may be desirable in many cases of 28-volt operation to use separate isolating resistors for each tube in the avc system unless the effects of higher contact potential tubes in increasing bias on all tubes of the avc system is acceptable. Of course, in some instances where a very high value of d-c diode load is employed, the diode contact potential may establish the bias for the tubes on the avc line and the use of separate isolating resistors would not be important.

Minimizing Effects of G_m Variations

Since the minimum bias for maximum gain for each tube of a lot is established by the grid leak, this method of bias is recommended instead of cathode bias for 28-volt operation. While cathode bias tends to smooth out tube variations, it can be shown that cathode bias will not minimize G_m variations except when the bias is so large that the average G_m is reduced more than can be tolerated in 28-volt operation. Grid leak bias is almost as effective for smoothing tube variations and is inherently available in most avc systems. For this reason all tube ratings published herewith are made with a 2-megohm grid leak (with the exception of voltage amplifiers which employ a 10-megohm leak) at zero external bias. The grid signal employed is 0.10 volts rms.

This signal is standard on the G_m test line of the tube plant and is employed in the laboratory so that data are directly useful for translation into test limits. For the condition of zero grid circuit resistance at 28 volts B supply the value of G_m observed varies negligibly as the grid signal is reduced from 0.1 v. For the condition of 2 megohms grid circuit resistance some grid current rectification occurs, and biases the grid back somewhat. Therefore higher measured values of G_m will be observed for grid signals less than 0.1 volt.

"High" G_m types show more change in G_m with signal level than "medium" G_m types. "Low" G_m tubes of a given type tend to show more change than "high" G_m tubes. For example, when the grid signal is reduced from 100 millivolts to 50 millivolts for type 12SH7 the highest tubes increase their observed G_m about 5 percent, while the lowest tubes increase it about 9 percent. For type 12SG7 the respective differences are 3.5 percent and 5 percent, and for type 12SK7 they are 1.2 percent and 1.5 percent. Thus the following data indicate

TABLE III—TYPICAL RESISTANCE-COUPLED AUDIO AMPLIFIER OPERATION OF PENTODES AT 28 VOLTS

TUBE TYPE	12SF7		12SJ7		9001	
HEATER VOLTAGE - VOLTS	12.6		12.6		6.3	
HEATER CURRENT - AMP.	0.15		0.15		0.15	
PLATE SUPPLY VOLTAGE - V	28		28		28	
GRID BIAS VOLTAGE - V	0		0		0	
GRID RESISTOR - MEGOHMS	10		10		10	
SCREEN GRID RESISTOR "	0.33	0.82	0.22	0.47	0.068	0.27
PLATE LOAD RESISTOR "	0.10	0.22	0.10	0.22	0.10	0.22
FOLLOWING GRID RES. "	0.82	1.0	0.22	1.0	0.82	1.0
PLATE CURRENT - μA	180	90	180	95	170	70
SCREEN GRID CURRENT - μA	90	25	60	35	90	35
AMPLIFICATION	23	35	34	47	35	52
MAX OUTPUT (5% DIST.) - V	3	4	4	4.5	3.5	4

slightly lower values and less uniformity than might be obtained in circuit practice.

The average characteristics of several pentode types for 28-volt operation are shown in Table I. The mutual conductance curves for remote cut-off pentodes are given in Fig. 2, and for sharp cut-off pentodes in Fig. 3. These curves are for the condition of zero grid circuit resistance, and the high value of G_m shown for some types at bias values less than about −0.75 volt will not be realized in r-f amplifier applications with 2-megohm grid leak bias (see Table I).

Transconductance Variations at 28-Volt Design Center

It is of practical interest to note the percentage variation in transconductance which occurs as the B supply voltage is varied. Some aircraft radio equipments must operate over a range of 22 volts minimum to 32 volts maximum, or −21 percent and +14 percent from a design center of 28 volts. From a cathode temperature standpoint tubes cannot be rated for supply voltage variations greater than ±10 percent for continuous operation. However, if equipments are to be measured for performance at extremes of voltage variation, Fig. 4 and 5 show the order of variation in stage gains to be expected for each tube type as the B voltage is varied (heater voltage constant). The disadvantage of "high G_m" tubes such as types 6AG5, 12SG7, and 12SH7 is apparent.

Typical transconductance variations as a function of heater voltage (B voltage constant) are illustrated in Fig. 6. Both effects must be tolerated and allowed for in equipment performance test specifications. Figure 6 also demonstrates that contact potential bias is to be preferred over fixed or cathode bias if variation in transconductance over a range of heater voltage is an important consideration.

There is one point which should be emphasized in connection with 28-volt operation of standard receiving tubes. It is that a tube rated for a very high transconductance at higher voltages will not necessarily exhibit a higher transconductance at 28 volts than the medium transconductance tubes such as the types 12SJ7, 12SK7, etc. The curves of Fig. 4 and 5 demonstrate this fact. Furthermore, many of the very high transconductance types are rated with −1.0 volt bias at maximum plate and screen voltage ratings, and no appreciable reduction in bias is obtained with grid leak bias. For tubes like types 12SJ7 and 12SK7 which are rated with −3.0 volts bias at maximum voltage ratings, it is possible to reduce the bias sufficiently for 28-volt operation that a value of transconductance is obtained equal to or better than that of the "high G_m" types. In addition, the "medium G_m" types exhibit tube-to-tube uniformity at 28 volts comparable to that obtained at maximum voltage ratings, while the "high G_m" types do not.

Selection of Tube Types

The comparative average transconductance and the typical range of variation between tubes of a given lot are illustrated in Fig. 7 for several types. This figure should assist the designer who is critical of product variations in the selection of types to be used. Figures 2 and 3 should be useful in the choice of types for a particular application. For most r-f and i-f applications with avc the 12SK7 appears to be a good selection both from the standpoint of average characteris-

(*Continued on page 379*)

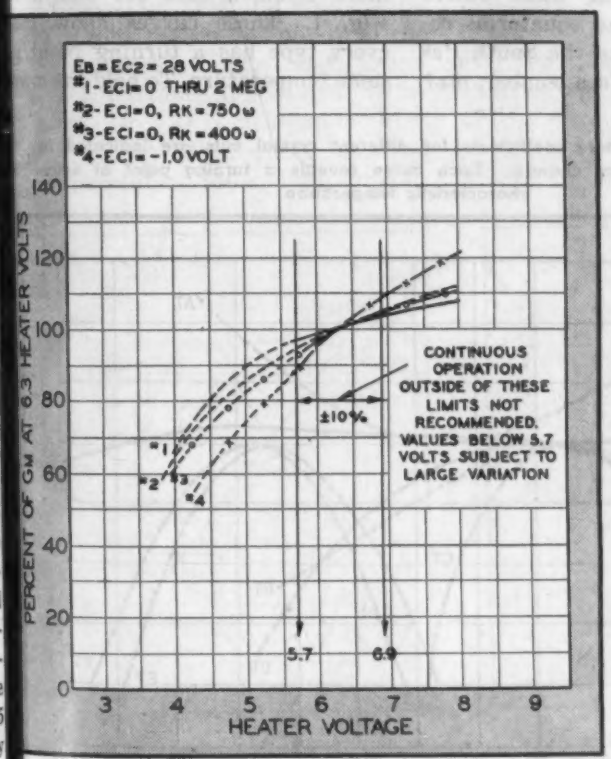


FIG. 6—Percentage variation of transconductance of type 9003 pentode heater voltage

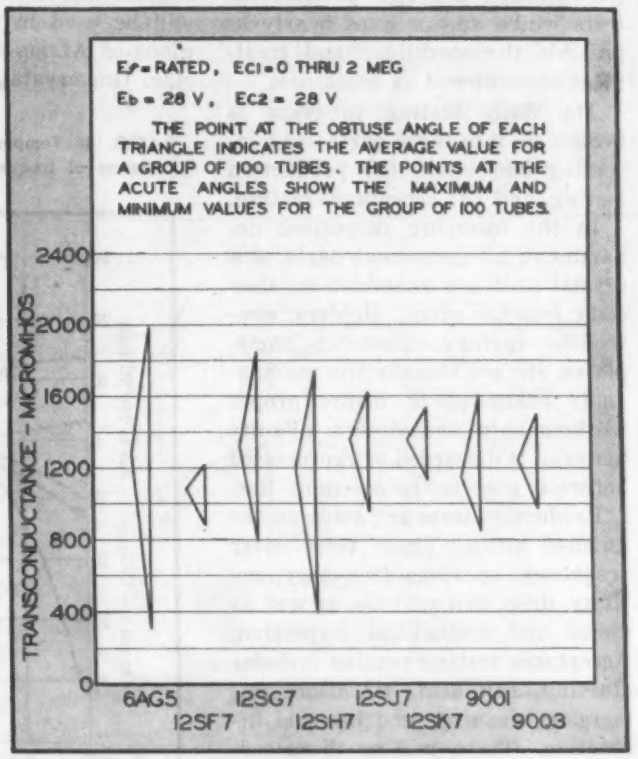
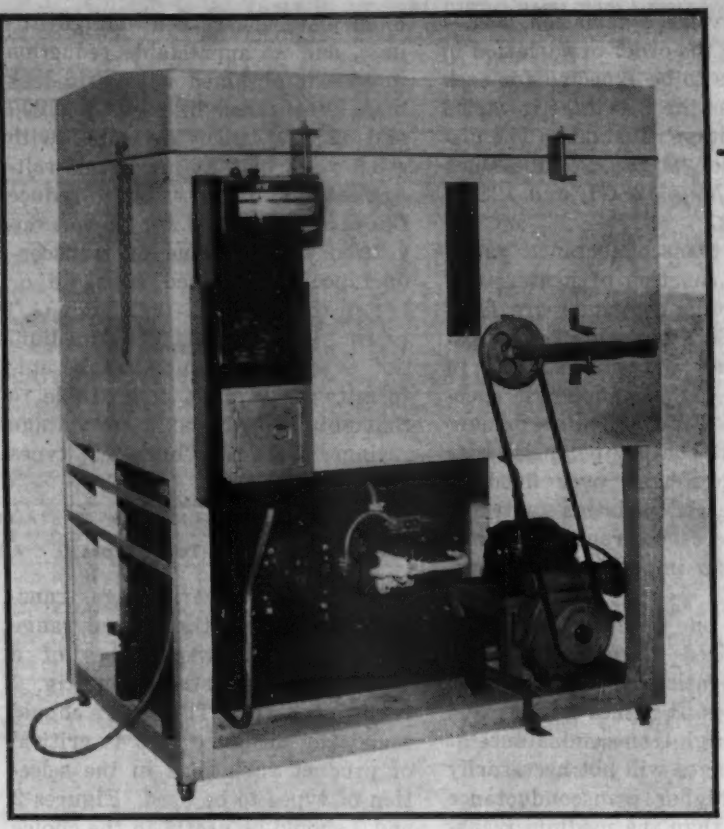


FIG. 7—Transconductance variation of r-f pentodes with 28-volt B supply

CRYSTAL T

By L. A. ELBL
Engineering Department
Crystal Products Co.
Kansas City, Mo.



Temperature-controlled testing box accommodates as many as 600 crystal units at a time. Manual checks are made at two-deg intervals over required temperature range. For resulting data, see Fig. 3

BEFORE CRYSTALS are shipped from the laboratory, they are put through a series of exacting tests which approach as nearly as possible the conditions and treatment encountered in actual use.

The daily testing program is broken up into three parts: (1) incoming inspection, (2) production testing, and (3) acceptance testing.

In the incoming inspection department, all component parts of a crystal unit are examined as they come into the plant. Holders, electrodes, springs, gaskets, nameplates, etc. are visually and mechanically examined to insure proper workmanship and design. Faulty material is discarded or reprocessed before it goes to the assembly line.

Production tests are made on the finished units. These tests cover frequency, spurious frequency, activity, drop, and altitude, as well as visual and mechanical inspection. Acceptance testing routine includes starting, full load, vibration, immersion, cleaning, and internal inspection. These will be discussed.

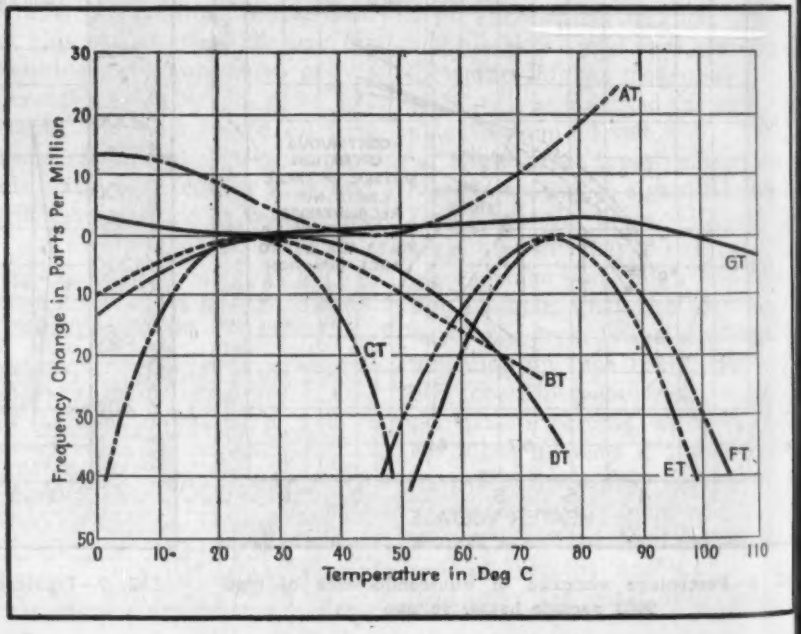
Crystals are expected to operate efficiently at widely different temperatures. Some, for instance, will be used in the frigid climates of Alaska and Siberia, while others will be used in the equatorial regions of Africa and the South Pacific. One crystal, in a bomber, may pass from equatorial ground temperatures to the sub-zero temperatures of the stratosphere in a few minutes. A good crystal must work efficiently, no matter what the temperature.

Crystal Tests

For the above reasons each crystal is tested, both for frequency and activity, over the entire temperature range of its anticipated use. A minimum activity and an allowable frequency deviation are set up and crystals which do not conform over the established temperature range are rejected.

Variation in frequency with a change in temperature, or temperature coefficient[1], is characteristic of the type of cut made. Frequency-temperature curves of some of the more common cuts are shown in Fig. 1. These curves show that every type has a turning point at some temperature. To hold the crys-

FIG. 1—Temperature coefficients for different crystal cuts are indicated in terms of frequency change. Each curve reveals a turning point at some characteristic temperature



TESTING TECHNIQUES

Step-by-step account of characteristic production and acceptance hurdles in the path of a crystal oscillator plate before its final approval, with details on procedures, interpretation of results, and methods of reclaiming initially faulty units

tal within frequency tolerances set up in the specifications, it is important that the turning point be at the middle of the temperature range to utilize the symmetry of the curve.

Turning point can be changed by increasing or decreasing the B (ZZ') angle. This is shown graphically in Fig. 2. The A and C angles also affect the turning point but to a much lesser degree. By way of an example, assume that a 5000 kc, BT-cut crystal is being tested from +90 deg C to −50 deg C. Suppose the specifications call for a maximum frequency deviation of not more than 0.02 percent. This means that the allowable deviation is ±1000 cycles. In Fig. 3 are shown several cases encountered in checking.

Case (1) is that of a good crystal having its peak in the middle of the temperature range and being within tolerance at both ends of the curve. No. (2) is mounted too high and is out of tolerance at room temperature. Some such crystals can be repaired and brought within tolerance by decreasing the air gap between crystal and electrodes. Usually, however, the crystal must be ground to the next higher frequency.

Example (3) is cut at the wrong angle, making it peak at the wrong temperature, so it cannot be used for this particular temperature range. No. (4) is mounted too low at room temperature and goes out of tolerance at both ends. This crystal can be repaired by very slight grinding and a thorough washing. No. (5) has a spurious frequency caused by coupling.[1] This crystal can be repaired by a slight change in dimensions of the blank.

Current Must Hold Up

Activity of a crystal is required to remain above a certain minimum over the entire temperature range.[2] First of all, activity is a function of the contour and geometric dimensions of the crystal blank. By leaving the thickness and length of a blank constant but changing the width, one can make activity go through a number of maxima and minima. A typical activity curve is shown in Fig. 4.

Contour of the faces of the blank is equally important—affecting the activity in a similar manner. In manufacture it is imperative that the geometrical dimensions and flatness required for obtaining maximum activity at a given frequency be determined experimentally before putting that frequency into actual production. Even though finishers have both the dimensions and contour as perfect as possible and have maximum activity of the crystal at room temperature, activity dips may occur at some point in the temperature range which will cause a crystal to fall below the activity minimum. In Fig. 5 are shown several common dips found in checking crystals.

In No. (1) the sharp dip over a small temperature range is usually caused by improper dimensioning of the blank, resulting in interfer-

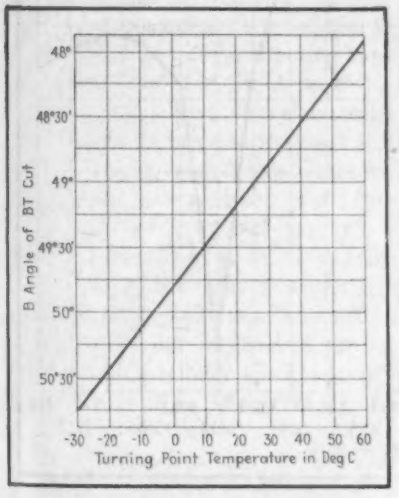


FIG. 2—Turning point temperature of a specific crystal cut depends in this manner on the B (ZZ') angle. This property is used to maintain tolerance

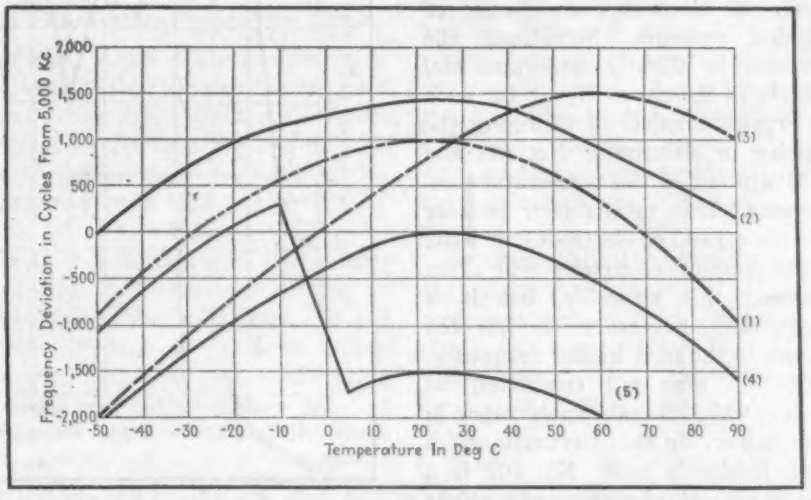
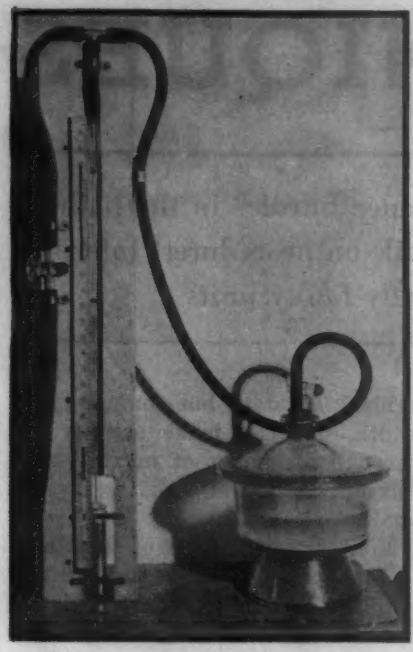


FIG. 3—Studies of five crystals under frequency-temperature test shows only No. 1 to be satisfactorily within 1000-cycle tolerance. Some of the others can be adjusted to requirements, some must be reprocessed by further grinding to another, higher frequency



Bell jar serves in altitude test when pressure is reduced to ½ in. of mercury. Ability of crystals to resist atmospheric penetration is vital in aircraft application

ing modes of vibration or coupling. A crystal of this sort is repaired by changing the dimensions of the blank slightly so as to eliminate interfering modes. There appears to be a correlation between the spurious frequencies mentioned previously and these activity dips. Where one occurs, the other is also present. Where the dip is a gradual one over a wide temperature range, as No. (2), it is termed a mechanical dip. This is usually caused by slippage of electrodes or change of spring pressure. Sometimes the crystal is slightly undersize and shifts in the case. Repair for such a crystal consists of changing the spring or electrodes. No. (3) and (5) dip out at the temperature extremes. This means poor contour on the crystal or electrodes, or both. Changing of electrodes will often remedy this situation, but it is sometimes necessary to lap the blank to the next higher frequency. No. (4) dips out completely at 0 deg, which reveals water vapor in the holder. In this circumstance, a new holder is used. No. (6) is a good crystal showing only slight variations due to slippage of the spring used to hold the electrodes in contact with the crystal.

Two other factors which affect overall activity of a crystal in the holder are size of air gap and condition of contact points on the electrodes. In the former case, resonance occurs at a certain relationship between frequency of the crystal and size of the air gap. When component motion of the faces of the crystal takes place in the direction of the electrodes, a supersonic air pulse is set up. This pulse travels across the air gap and is reflected back to the crystal.

Supersonic Interference

When the total path traveled by the air pulse is equal to the wavelength of the supersonic wave, interference occurs as the pulse returns to the crystal surface. Thus, for any particular frequency, there is a certain size of air gap at which interference occurs and causes a decrease in activity. The dimensions of a resonant air gap can be calculated, for any frequency, from the formula

$$g = \frac{v}{2f} \qquad (1)$$

where g is dimension of the air gap in thousandths of an inch, v is velocity of the supersonic pulse (sound) at a particular temperature, and f is frequency of crystal.

By way of illustration, consider an 8 Mc crystal at 20 deg C. Velocity of sound at this temperature is 1130 fps. Substituting in Eq. (1)

$$g = \frac{1130 \times 12}{2 \times 8 \times 10^6} = 0.00084 \text{ in.}$$

Air gap resonance has much less effect in thickness-shear oscillators than in pure thickness oscillators.

Friction Resists Activity

The second factor, condition of the contact points of electrodes, is important because friction between the electrodes and the crystal decreases activity. Electrodes are lapped perfectly flat and then polished on very fine carborundum paper or with optical powder. Reducing friction increases activity.

Too much spring pressure will often decrease activity since it inhibits vibration of the crystal. However, the spring has to prevent slippage of the crystal so the problem becomes one of having precisely the right pressure.

Types of Apparatus

Testing equipment, for making the temperature runs, varies widely in design. However, there are two general types: (1) equipment to test each crystal continuously over the entire temperature range and (2) equipment in which the temperature can be held constant at intervals over the temperature range while a large number of crystals are

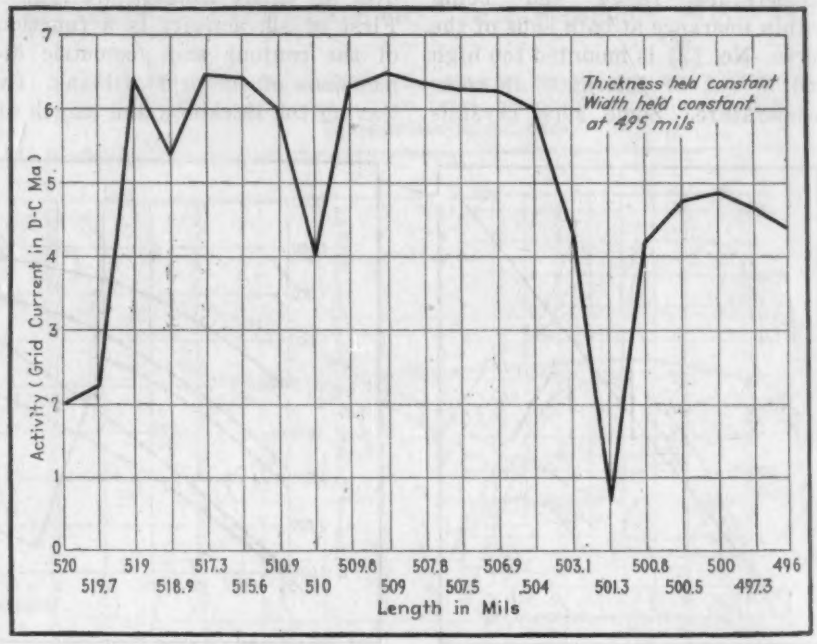


FIG. 4—Electrical activity, at constant thickness and width of crystal, relates to length in accordance with this typical curve. Satisfactory crystal must not have an activity dip going below the established minimum anywhere in temperature range

checked at each interval for activity and frequency. Recording of frequency and activity may be either manual or automatic. The automatic self-recording test apparatus is, of course, the most convenient to use. But it does not adapt itself to mass production so well as manual means—the reason being that it entails prohibitive cost to have enough testing units to care for large numbers of crystals. Most laboratories use a simple insulated box, similar to that illustrated, which will accommodate from 50–600 crystals at a time. These are placed in an indexed wheel inside the box and the crystals checked at intervals of two degrees over the entire range.

In the general run of crystals approximately 85 percent pass the activity and frequency tests on the temperature run. Of the 15 percent failures, about 14 are activity and 1, frequency rejects. Rejected crystals go to the repair department where they are reworked. About 50 percent of the repaired crystals pass upon being retested. Those thrown out on the second run are again reworked, being checked for contour, twinning, and flaws and on the next temperature run, about 25 percent pass. General practice is to discard those failing on the third run.

Shock, Frequency, and Sealing

Another production test is used for determining the mechanical stability of a crystal. Each unit is permitted to fall five times from a height of eight inches to a horizontal two-inch oak plank (most plants have substituted several sharp taps on an oak plank for the drop test). After the drop test, there must be no resulting damage to the unit and activity must not have changed more than 10 percent nor frequency more than 0.002 percent.

Crystals are tested at room temperature for spurious frequencies. This is done by placing the unit in a tuned-plate oscillator and tuning the plate circuit over the frequency range (5–10 Mc). The crystal must oscillate at a single frequency.

For testing the seal on aircraft crystals, a reduced pressure test is used. Each unit must be sealed so that when subjected to an absolute external pressure of ½ in. of mercury, ten minutes is required for the pressure inside the unit to drop to ¼ atmosphere. Testing is done with a device as illustrated which measures the ion current through each crystal when a d-c potential of 1000–2000 volts is applied to the crystal unit in series with a high resistance.

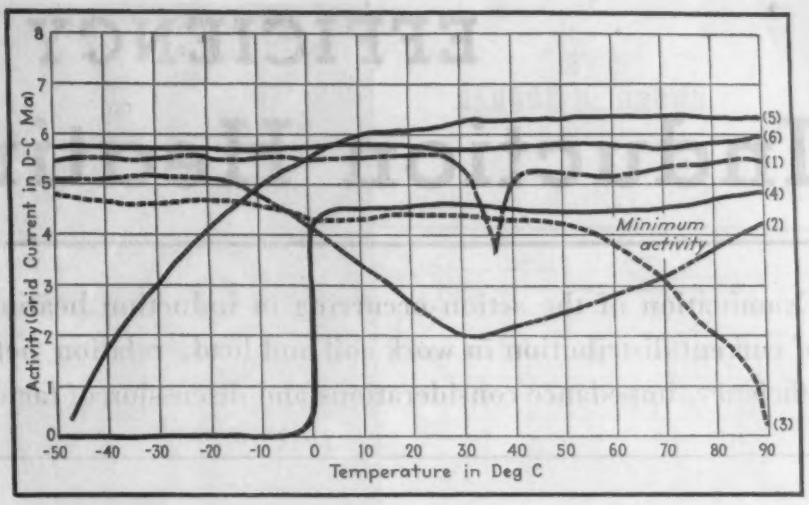


FIG. 5—Activity dips in production-tested crystals take these forms, each of which reveals some characteristic trouble. For instance, No. 4 exhibits presence of water vapor which halts activity at freezing point

Here is the purpose of this test. If a crystal has an air leak, internal pressure decreases, due to a decrease in atmospheric pressure, as the plane carrying it ascends. When the plane is in a dive, or descends, atmospheric pressure on the outside increases—forcing air into the holder. If the plane goes through a cloud where humidity is high, the entering air is moist. This moisture condenses in the holder, short-circuiting the unit.

Examination Ends Production Checks

Close, visual external inspection of the finished product is the last production test. Causes for most common rejections are bad prongs, scratches or chips in the Bakelite case, and poor lettering or stamping. In each circumstance these are set aside to be repaired. Bad prongs are caused by faulty soldering of the tips or scratches exposing the brass. Prongs are made of nickel- or chrome-plated brass. If the brass is exposed the crystal is rejected because brass tarnishes. In these cases, the prongs are resoldered, smoothed down, and replated electrolytically. Scratched or chipped holders are replaced with new ones. If the stamping is bad, it is usually buffed off and re-done. In some cases addition of whiting will remedy the situation.

Acceptance Tests

At this point, crystal units are submitted to inspectors for acceptance. These inspectors do not check every crystal through all their tests. In most cases, they make a spot or type test. This involves taking at random a group of 30 crystals out of each thousand. These are submitted to visual and mechanical inspection; frequency, activity, starting, spurious frequency, full load, drop, seal, vibration, and immersion tests; cleaning; and internal inspection.

The manufacturer submits crystals in groups of 1000. Inspectors select 30 at random from the group of 1000 and run them through the various tests. If more than one crystal fails out of the group of 30, another 30 crystals is selected from the original 1000. If 3 or more units fail out of the two groups of 30, (60 crystals) the original 1000 crystals are rejected and cannot be shipped.

At this point, the manufacturer may rework the thousand crystals and re-submit 30 for another spot check, or he may submit the entire 1000 units, *without* reworking, to be run through all the acceptance tests.

Acceptance tests are primarily the same as the production tests with these exceptions: In the starting test, a crystal is measured for

(*Continued on page* 380)

EFFICIENCY OF Induction Heating Coils

Examination of the action occurring in induction heating of metals, including analysis of current distribution in work coil and load, relation between frequency and coupling efficiency, impedance considerations and discussion of factors affecting choice of frequency

IN induction heating of metals, the object to be heated is placed in the field of a suitably designed coil which is carrying an alternating current. Currents are then induced in the object, generating heat without contact. The action is that of a transformer with the secondary short-circuited.

Equivalent Circuit for Induction Heating

In the circuit of Fig. 1,* a coil of inductance L_1 and resistance R_1 is placed across the terminals of a generator which is developing a voltage V_1. The generator may be a rotating machine, a spark-gap oscillator, or a vacuum-tube oscillator. A piece of metal to be heated may be represented as the shorted secondary turn with a resistance R_2 and an inductance L_2. The circuit equations are

$$V_1 = [R_1 + j\omega L_1]\, I_1 + j\omega M I_2 \qquad (1)$$

and

$$0 = j\omega M I_1 + [R_2 + j\omega L_2]\, I_2 \qquad (2)$$

where f is the frequency in cycles per second, ω equals $2\pi f$, and M is the mutual inductance in henrys. Elimination between these two equations gives the impedance presented to the terminals of the generator.

$$V_1/I_1 = R_1 + j\omega L_1 + \frac{(M)^2}{R_2 + j\omega L_2}$$

$$= R_1 + \frac{(\omega M)^2 R_2}{R_2^2 + (\omega L_2)^2} + j\omega\left\{L_1 - \frac{(\omega M)^2 L_2}{R_2^2 + (\omega L_2)^2}\right\} \qquad (3)$$

Thus we see that the primary resistance is increased by the presence of the load or shorted turn, while the inductance of the work coil has decreased.

Let $Q = \omega L_2/R_2$. Then the increase in resistance due to the presence of the metal to be heated is

$$\triangle R_1 = \left(\frac{M}{L_2}\right)^2 R_2 \frac{Q^2}{Q^2+1} \qquad (4)$$

and

$$\triangle L_1 = -\left(\frac{M}{L_2}\right)^2 L_2 \frac{Q^2}{Q^2+1} \qquad (5)$$

Equations for Efficiency

The efficiency of the heating circuit, that is, the ratio of the power transferred to the work to the total power supplied is

$$\text{Efficiency} = \frac{\triangle R_1}{R_1 + \triangle R_1} = \frac{\left(\frac{M}{L_2}\right)^2 R_2 \frac{Q^2}{Q^2+1}}{R_1 + \left(\frac{M}{L_2}\right)^2 R_2 \frac{Q^2}{Q^2+1}} \qquad (6)$$

The Q of the secondary circuit is generally much larger than unity for most of the frequencies used for induction heating. The variation of the factor $Q^2/(Q^2+1)$ as a function of Q is shown in Fig. 2. It is seen that as Q becomes large, the factor in question approaches unity. If we make this limiting assumption, Eq. (6) becomes

$$\text{Efficiency} = \frac{\left(\frac{M}{L_2}\right)^2 \frac{R_2}{R_1}}{1 + \left(\frac{M}{L_2}\right)^2 \frac{R_2}{R_1}} \qquad (7)$$

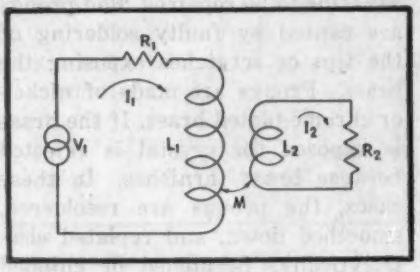


FIG. 1—Equivalent circuit for induction heating

At high frequencies, the current flowing in a conductor tends to concentrate near the surface. The current density drops off exponentially with the depth. A depth, s, may be defined as the thickness of a layer of metal which, if it carried uniform current, would present the same resistance as the total metal sheet carrying the exponentially decaying current. Then

$$s\ (\text{centimeters}) = \frac{1}{2\pi\sqrt{10^{-9}\mu_r \sigma f}} \qquad (8)$$

where

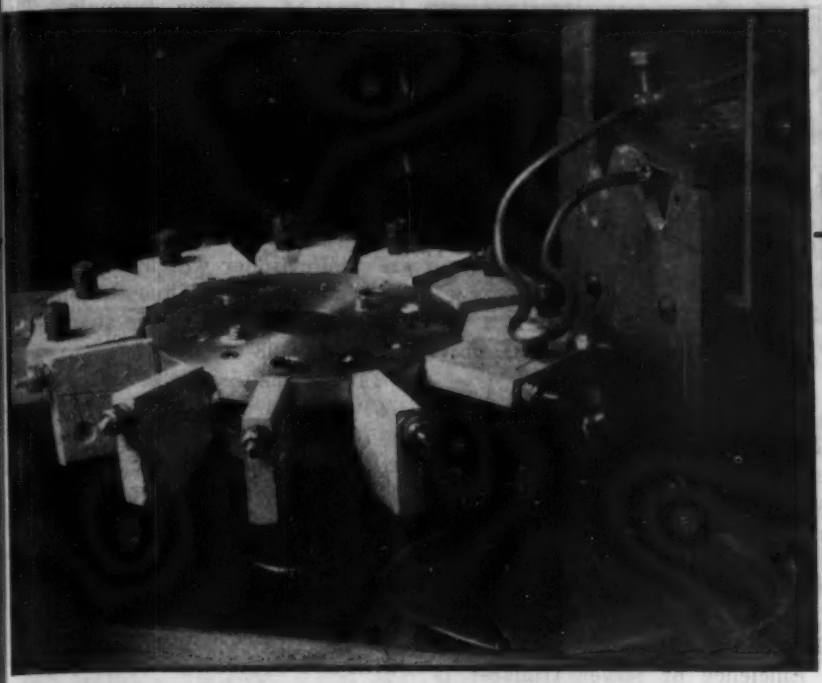
μ_r = the relative permeability of the metal
σ = the conductivity of the metal (mhos for a centimeter cube)
f = frequency (cycles per second)

Since this layer varies inversely as the square root of the frequency, it may be shown that the resistance varies directly as the square root of the frequency. The preceding statements are predicated on the assumption that the metal in question has a thickness several times greater than the skin thickness, s.

Now, if the metal which is placed in the work coil has a thickness or a diameter which satisfies these requirements, the resistance R_2 which appears in Eq. (7) will vary as the square root of the frequency. However, the same statement holds true for the resistance of the work coil, R_1. In this case, the ratio R_2/R_1 will be simply a constant which is independent of frequency, and the effi-

* This is the circuit treated briefly by C. B. Kirkpatrick, Magnetic Induction Field of Air-Core Coils, *Wireless Engineer*, XX, No. 239. August, 1943, p. 378.

By
GEORGE H. BROWN
RCA Laboratories
Princeton, New Jersey



Single-turn work coil being used for localized hardening of the slotted tops of set screws. The rotating jig automatically dunks each screw in the cooling tray

ciency also becomes independent of frequency.

It should be remembered that we have assumed that Q is large, and that the skin thickness is small compared to thickness or diameter of the conductors in question. Also, it should be noted that this reasoning cannot be extrapolated into the extremely high frequencies where capacitance effects must be taken into account.

Factors Affecting Choice of Frequency

Since the efficiency is independent of frequency, it is interesting to examine other factors which may influence the choice of frequency. In a vacuum-tube oscillator, the power is limited by the characteristics of the particular vacuum tubes used in the oscillator. Then, for a fixed power and large values of Q, the current in the primary is

$$I_1 = \sqrt{\frac{P}{R_1 + \Delta R_1}} = \sqrt{\frac{P}{R_1 + \left(\frac{M}{L_2}\right)^2 R_2}}$$

$$= \frac{1}{\sqrt{R_1}} \sqrt{\frac{P}{1 + \left(\frac{M}{L_2}\right)^2 \frac{R_2}{R_1}}} \quad (9)$$

If R_2/R_1 is a constant ratio independent of frequency, the current in the primary for a constant power is inversely proportional to the square root of the primary resistance. But this resistance is directly proportional to the square root of the frequency, so that

$$I_1 \propto 1/f^{0.5} \quad (10)$$

Under the assumption we have been making, the inductance at the input terminals is independent of frequency. Also, the reactance at these terminals is generally large compared to the resistance, so that the voltage at the terminals is

$$V_1 = \omega(L_1 + \Delta L_1)\, I_1 \quad (11)$$

Taking Eq. (10) into consideration, we see that

$$V_1 \propto f^{0.75} \quad (12)$$

We may thus sum up our observations, remembering the assumptions that have been made during the course of the development:

1. The efficiency of power transfer is independent of frequency.
2. The reactance at the input terminals of the work coil varies directly with frequency.
3. The resistance at the terminals of the work coil varies with the square root of the frequency.
4. The current in the work coil, for a constant power input, varies inversely as the one-fourth power of the frequency.
5. The voltage in the work coil, for a constant power input, varies directly as the three-fourths power of the frequency.

To test the foregoing conclusions, experimental data was assembled

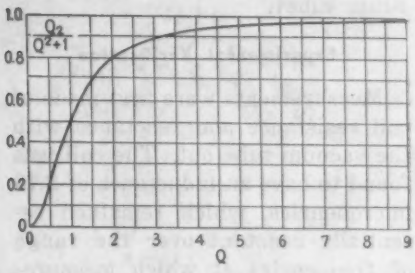


FIG. 2—Variation of factor in Eq. (6) with Q of induction-heating secondary circuit

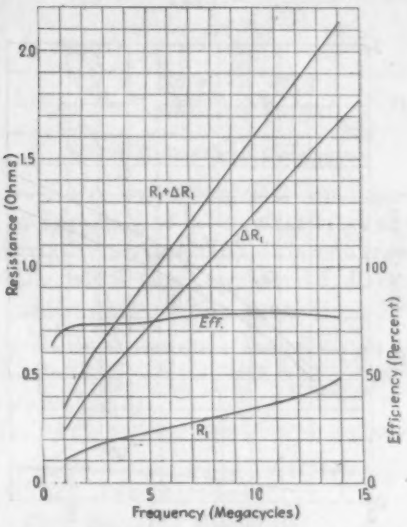


FIG. 3—Resistance and efficiency data for a work coil used in inductively heating an RCA-6A6 vacuum tube

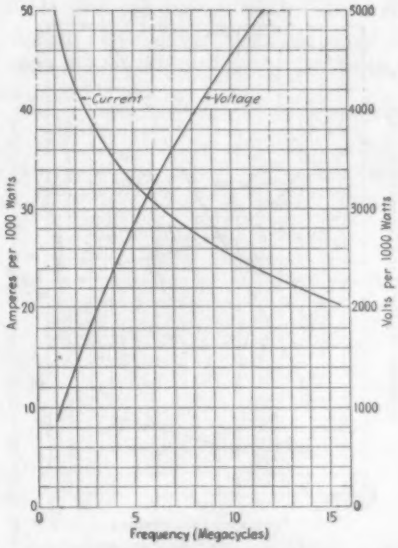


FIG. 4—Current and voltage values on the work coil used to heat the RCA-6A6 vacuum tube when coil power is 1000 watts

concerning a coil placed around a vacuum tube. The coil in question was a helix or solenoid, consisting of copper tubing which had a diameter of 5/32 inch, wound to form eleven turns which were 2½ inches in diameter. The length of the coil was 3¼ inches. The work or object to be heated was an RCA-6A6 vacuum tube†.

Experimental Verification

Measurements were first made of coil resistance and reactance with the vacuum tube out. The coil was found to have an inductance of 2.76 microhenries, which remained essentially constant over the range of frequencies at which measurements were made. The resistance

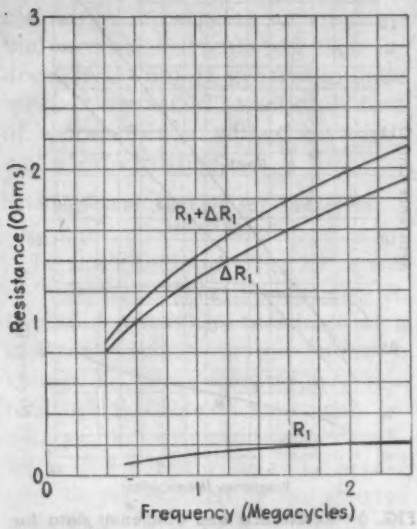


FIG. 5—Resistance values of multi-turn work-coil closely coupled to steel load

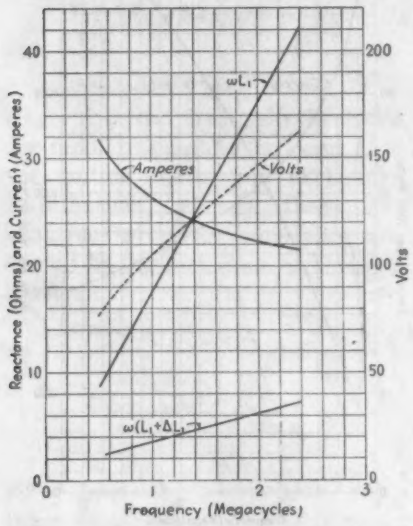


FIG. 6—Reactance, voltage and current of multi-turn work-coil closely coupled to steel load

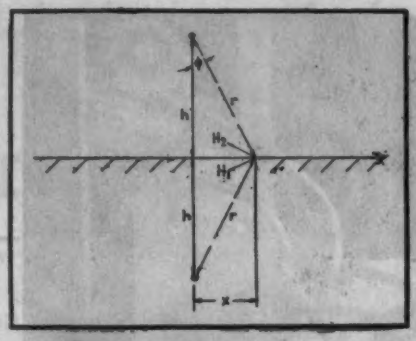


FIG. 7—Current-carrying conductor above and parallel to a conducting sheet

R_1 varied with frequency as shown in Fig. 3. Then the vacuum tube was inserted in the coil and the measurements repeated. The inductance decreased only about one one-hundredth of a microhenry. The new resistance $R_1 + \Delta R_1$ is shown in Fig. 3.

Efficiency of power transfer is also shown in Fig. 3. This curve was computed directly from the measured values of resistance. We see that the efficiency lies between 72.0 and 78.5 percent for all frequencies between 1 and 15 Mc.

The current in the coil under load conditions and the voltage across the terminals of the coil are shown in Fig. 4 for the case where the available power is 1000 watts. The coil current is approximately 50 amp at a frequency of 1 Mc, and decreases to about 20 amp when the frequency has increased to 15 Mc. Since Fig. 3 shows that the efficiency is approximately the same at the two frequencies, the coil will not get any hotter with the increased current at the low frequency than it will at the higher frequency with less current. On the other hand, the voltage is less than 1000 volts at the low frequency while it rises to more than 5000 volts at 15 Mc.

Heating a Steel Cylinder

The high voltages shown here are due to the loose coupling. Closer coupling to the work will make ΔL_1 have a greater numerical value, so that the total reactance will be decreased. This important effect of close coupling will be illustrated by means of another example. The work coil was very similar to the one used for coupling to the RCA-6A6 tube. Copper tubing which had a diameter of 5/32 in. was wound to form 11 turns. The total length of the coil was 3¼ in., and the inside diameter of the coil was 4.92 cm. This coil was placed around a steel cylinder which had a diameter of 4.76 cm. Thus the spacing between the coil and the steel cylinder was 0.08 cm.

The measured values of R_1 and $R_1 + \Delta R_1$ are shown in Fig. 5, together with the calculated values of ΔR_1. The efficiency calculated from Eq. (6) is exactly 90 percent over the range of frequencies at which measurements were made so there is no need to show the results in curve form.

The measured values of reactance with and without the steel cylinder are shown in Fig. 6. Because of the close coupling, the reactance drops a great deal when the cylinder is inserted. The effect of this

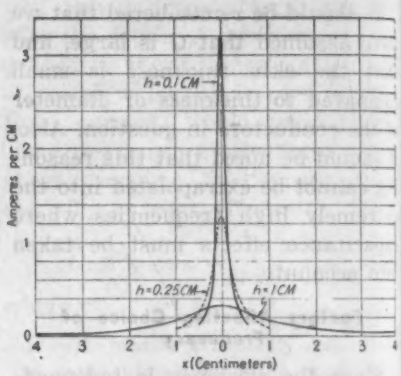


FIG. 8—Current distribution in the sheet for a filamentary conductor at various heights above the sheet

is remarkable when the voltage across the coil is considered. Figure 6 shows that this voltage lies between 80 and 160 volts when the operating frequency is between 0.5 and 2.4 Mc. The current in the coil as a function of frequency is also shown in Fig. 6.

Analysis of Single-Turn Coupling Coil

At times, it becomes necessary to couple to a cylinder of metal with a single-turn coil closely spaced to the work. Then the coil impedance is very low and transformers must be used to obtain efficient operation. This is true in many sol-

† An RCA-6A6 tube was chosen as a convenient load for obtaining these data, but this heating operation was simply a laboratory experiment which had no connection with the manufacture of this type of tube.

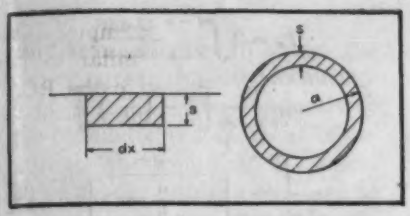


FIG. 9 (above, left)—Current-carrying patch on the surface of a conducting sheet

FIG. 10 (above, right)—Current distribution on a cylindrical conductor far removed from sheet

dering operations and in the practice of scanning for case-hardening of steel by self-quenching. Before considering the transformers which may be used in this operation, it seems desirable to examine the action of the single-turn coupling coil. If the cylinder to be heated is of large diameter, the case may be simplified by treating the problem as a straight conductor parallel to a flat sheet of metal of great thickness.

In Fig. 7, we see a long conductor parallel to a conducting layer and h units above the layer. This filamentary conductor is carrying current into the paper. For the purpose of computing fields above the metal layer, we place another conductor or image h units below the surface of the layer. This image is effectively a conductor carrying current out of the paper. At a point x units along the conducting layer, as shown in Fig. 7, the current-carrying conductor above the metal sheet sets up a magnetic intensity vector H_1 which is at right angles to the line r drawn from the conductor to the point in question. The magnitude of this magnetic intensity is

$$H_1 = I/2\pi r \qquad (13)$$

where $r = \sqrt{h^2 + x^2}$. The magnetic intensity due to the image is H_2 and is exactly equal to H_1 in magnitude but points in the direction shown in Fig. 7. The vector sum of these two vectors is parallel to the surface of the layer and has a magnitude which is

$$H = 2H_1 \cos\phi = 2h\,H_1/r \qquad (14)$$

Now if the layer is a good conductor, the current in the layer will be concentrated near the surface. Then the current density J in amp per cm in the little patch shown in Fig. 7, where the patch is of unit width and x and h are in cm, is

$$J = H = \frac{I}{\pi}\frac{h}{h^2 + x^2} = \frac{I}{\pi h}\frac{1}{1 + \left(\frac{x}{h}\right)^2} \qquad (15)$$

Current Distribution in Metal Sheet

Figure 8 shows the current distribution in the sheet for a number of values of h, with the current I in the conductor, and flowing out of the paper, equal to one ampere. We see that as the conductor is placed closer to the layer or sheet, the current density increases directly below the conductor, but drops off quickly in a lateral direction.

To sum up all of the current in the sheet, integrate Eq. (15) from $x = -\infty$ to $x = +\infty$. Then

$$\int_{x=-\infty}^{x=+\infty} J\,dx = \frac{2hI}{\pi}\int_{x=0}^{x=\infty}\frac{dx}{h^2 + x^2} = \frac{2}{\pi}hI\frac{1}{h}\tan^{-1}\left(\frac{x}{h}\right)\Bigg|_{x=0}^{x=\infty} = I \qquad (16)$$

The total current flowing in the sheet is thus equal to the current assumed to be flowing in the single conductor.

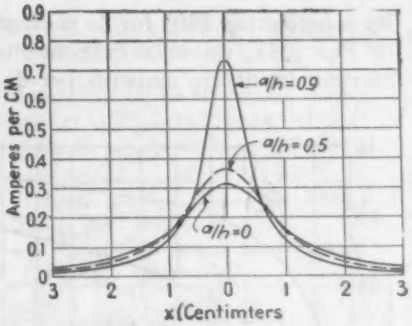


FIG. 11—Current distribution in the conducting sheet when the conductor has a finite radius and $h = 1.0$ cm

We will now proceed with a consideration of the losses in the sheet. The current density J flows out of the paper in a small patch of unit lateral width and of thickness s. This dimension s (Fig. 9) is the skin thickness given by Eq. (8). The current flowing out of the patch shown in Fig. 9 is $J\,dx$. The resistance of the patch shown, with a length of one centimeter into the paper, is

$$dR = 1/\sigma s\,dx \qquad (17)$$

The watts lost (I^2R) in this small element is

$$(J\,dx)^2\,dR = \frac{J^2\,dx}{\sigma s} \qquad (18)$$

If we now substitute Eq. (15) in (18) and integrate from $x = -\infty$ to $x = +\infty$, we have the power lost in the sheet in a slice taken at right angles to the cylindrical conductor, where the thickness of the slice in the direction along the conductor is one centimeter. If P_m equals the power lost in a 1-cm slice of the metal sheet,

$$P_m = \frac{1}{\sigma s}\int_{x=-\infty}^{x=+\infty} J^2dx = \frac{2h^2I^2}{\pi^2\sigma s}\int_{x=0}^{x=+\infty}\frac{dx}{(h^2 + x^2)^2} \qquad (19)$$

But

$$\int_{x=0}^{x=\infty}\frac{dx}{(h^2 + x^2)^2} = \frac{1}{2h^3}\tan^{-1}\left(\frac{x}{h}\right)\Bigg|_{x=0}^{x=\infty} = \frac{\pi}{4h^3} \qquad (20)$$

so that

$$P_m = \frac{I^2\pi^2}{2\pi\sigma sh} = \frac{I^2}{h}\sqrt{\frac{10^{-9}\mu_c f}{\sigma}} \qquad (21)$$

Finite Cylindrical Conductor

Since the cylindrical conductor generally has a conductivity and relative permeability different from the metal sheet, we should distinguish between the quantities. Let

σ_m = conductivity of the metal sheet
σ_c = conductivity of the current-carrying conductor placed parallel to the sheet
μ_m = relative permeability of the metal sheet
μ_c = relative permeability of the current-carrying conductor

Then Eq. (21) should be

$$P_m = \frac{I^2}{h}\sqrt{\frac{10^{-9}\mu_m f}{\sigma_m}} \qquad (22)$$

If the conductor of radius a is placed far enough from the sheet so that the presence of the sheet does

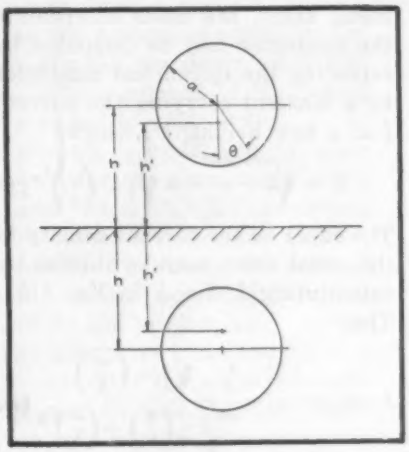


FIG. 12—Cross-section of cylindrical conductor and image in the sheet

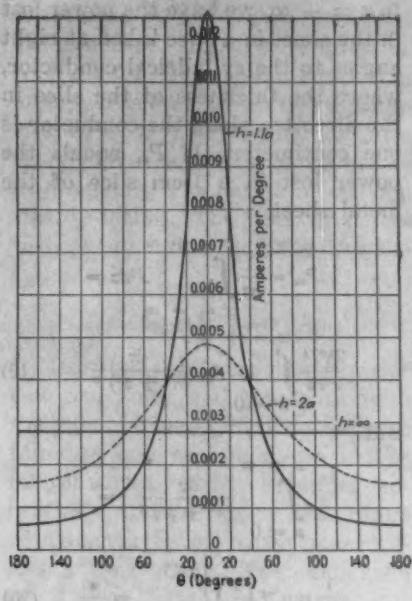


FIG. 13—Current distribution on the cylindrical conductor occasioned by the presence of the metal sheet

not alter the current distribution on the conductor, the current on the conductor will flow in a thin layer s equal to the skin thickness (Fig. 10). Then the power lost in a centimeter of conductor is

$$P_c = \frac{I^2}{2\pi\, a s_c \sigma_c} = \frac{I^2}{a}\sqrt{\frac{10^{-9}\mu_c f}{\sigma_c}} \qquad (23)$$

and the ratio of the power spent in the metal sheet to the power lost in the conductor is

$$P_m/P_c = \frac{a}{h}\sqrt{\frac{\mu_m \sigma_c}{\mu_c\, \sigma_m}} \qquad (24)$$

Before interpreting Eq. (24), examine the effect of the altered current distribution on the sheet and on the conductor due to close spacing.

When the conductor has a finite radius, a, with the axis of the conductor a distance, h, above the metal sheet, the fields external to the conductor may be computed by replacing the cylindrical conductor by a filament carrying the current I at a new height, h', where

$$h' = \sqrt{h^2 - a^2} = h\sqrt{1 - \left(\frac{a}{h}\right)^2} \qquad (25)$$

The effect on the current density in the metal sheet may be studied by substituting h' for h in Eq. (15). Then

$$J\ (\text{amp per cm}) = \frac{I}{\pi h}\,\frac{\sqrt{1-\left(\frac{a}{h}\right)^2}}{1-\left(\frac{a}{h}\right)^2+\left(\frac{x}{h}\right)^2} \qquad (26)$$

The current density distribution is shown in Fig. 11 for a number of values of the radius, where the height of the conductor is equal to one centimeter. Increasing the radius of the cylinder has the same effect as bringing a thin filament closer to the metal sheet.

The power loss in the metal sheet may be obtained by substituting h' for h in Eq. (22), with the result that

$$P_m = \frac{I^2}{h}\sqrt{\frac{10^{-9}\mu_m f}{\sigma_m}} \cdot \frac{1}{\sqrt{1-\left(\frac{a}{h}\right)^2}} \qquad (27)$$

Current Distribution in Cylinder

The current distribution around the surface of the cylindrical conductor may be obtained by using the construction of Fig. 12. By means of a tedious algebraic construction, it may be shown that the current density on the surface of the conductor, confined to a layer s_c centimeters in thickness, is

$$J\ (\text{amp per radian}) = \frac{I}{2\pi}\,\frac{\sqrt{1-\left(\frac{a}{h}\right)^2}}{1-\frac{a}{h}\cos\theta} \qquad (28)$$

By substituting 360° for 2π radians in Eq. (28), we may express the current density in amperes per degree. This has been done in constructing the curves of Fig. 13. The current density distribution depends only upon the ratio of radius to height. When the conductor is brought very close to the metal sheet, the current on the conductor crowds around to the side closest to the sheet.

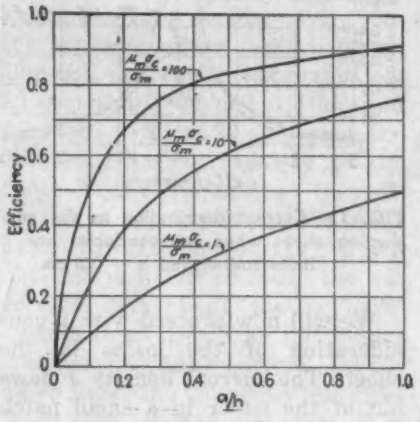


FIG. 14—Coupling efficiency of cylindrical conductor parallel to a metal sheet

The power loss in the conductor is found by integrating the I^2R loss around the circumference of the conductor. Then

$$P_c = 2\int_{\theta=0}^{\theta=\pi} \frac{(J\,d\theta)^2}{\sigma_c s_c a\, d\theta} = \frac{I^2}{2\pi^2 a\,\sigma_c s_c}\left[1-\left(\frac{a}{h}\right)^2\right] \int_{\theta=0}^{\theta=\pi} \frac{d\theta}{\left[1-\frac{a}{h}\cos\theta\right]^2} \qquad (29)$$

The integral itself is equal to

$$\frac{\pi}{1-\left(\frac{a}{h}\right)^2}\,\frac{1}{\sqrt{1-\left(\frac{a}{h}\right)^2}}$$

so that

$$P_c = \frac{I^2}{2\pi a s_c\,\sigma_c}\,\frac{1}{\sqrt{1-\left(\frac{a}{h}\right)^2}} = \frac{I^2}{a}\sqrt{\frac{10^{-9}\,\mu_c f}{\sigma_c}}\,\frac{1}{\sqrt{1-\left(\frac{a}{h}\right)^2}} \qquad (30)$$

If we now divide Eq. (27) by Eq. (30), we obtain

$$P_m/P_c = \frac{a}{h}\sqrt{\frac{\mu_m\,\sigma_c}{\mu_c\,\sigma_m}} \qquad (31)$$

It is a somewhat surprising fact that this result is identical with the result shown in Eq. (24) which was deduced from simple assumptions which did not take into account the redistribution of current due to the finite conductor size.

Since in inductive heating the coupling coil is usually made of copper, the relative permeability μ_c may be set equal to unity for simplicity. The efficiency is obtained from Eq. (31) in the following manner.

$$\text{Efficiency} = \frac{P_m}{P_m + P_c} = \frac{1}{1+\frac{P_c}{P_m}} = \frac{1}{1+\frac{h}{a}\sqrt{\frac{\sigma_m}{\mu_m\,\sigma_c}}} \qquad (32)$$

Efficiency Curves

Figure 14 shows the variation of efficiency with the ratio a/h. The need for close conductor spacing is

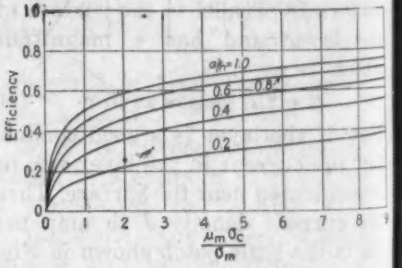


FIG. 15—Coupling efficiency as a function of conductivity

eadily seen. Figure 15 shows the fficiency curves replotted as a function of $\mu_m\sigma_c/\sigma_m$. The conductivity f the conductor is important in determining the coupling efficiency. Where a copper conductor is used to ouple to iron, the coupling effiency may become high. However, is sometimes necessary to heat a opper article by induction. At the tart of the heating cycle, the ratio $/\sigma_m$ is unity ($\mu_m = 1$ for copper). rom Fig. 15, we see that the best ossible efficiency is 0.5 when the adius of the conductor is equal to e height above the sheet. Howver, for practical purposes a/h is ss than unity, so that the coupling fficiency will be less than 50 perent at the start of heating. Forunately, the picture does not conue to be so gloomy. The coupng coil or conductor is usually hol- w tubing through which cooling ater flows, so that the conductivy of the conductor does not change time passes. The load begins to eat so that its conductivity deeases. This results in an imrovement in efficiency so that the nductivity decreases still faster, nd soon the efficiency assumes reasonable proportions.

If the heating coil is wrapped round a cylindrical load which has a radius many times larger than the diameter of the conductor which makes up the coil and large compared to the spacing between the coil and the work, we may use these results obtained for a conductor parallel to a flat sheet. If the circumference of the load is C centimeters, the resistance of a single-turn coil may be obtained from Eq. (27) and (30). This resistance is

$$R = \frac{C}{a}\frac{\sqrt{\frac{10^{-9}f}{\sigma_c}}}{\sqrt{1-\left(\frac{a}{h}\right)^2}}\left[1+\frac{a}{h}\sqrt{\frac{\mu_m\sigma_c}{\sigma_m}}\right] \quad (33)$$

Characteristic Impedance of Load

To obtain the reactance, we must first have available the expression for the characteristic impedance of the conductor over the flat sheet. This is

$$Z_c = 60\log_e\left[\left(\frac{h}{a}\right)\left(1+\sqrt{1-\left(\frac{a}{h}\right)^2}\right)\right] \quad (34)$$

SUMMARY OF DATA IN EXAMPLE FOR THREE VALUES OF h

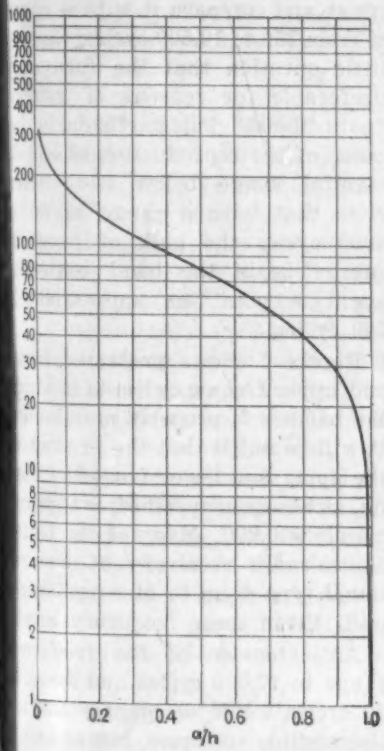
h (cm)	0.44	0.54	0.64
Efficiency (%)	84.2	81.4	78.5
R (ohms)	0.0195	0.0156	0.0131
Z_c (ohms)	73	87	97
X (ohms)	0.23	0.273	0.304
I (amp for 1000 w)	226	253	276
V (volts for 1000 w)	52	69	84
I (amp for 100,000 w)	2260	2530	2760
V (volts for 100,000 w)	520	691	840

This characteristic impedance as a function of a/h is shown in Fig. 16.

The single-turn coil around the load is usually fed in push-pull. Then the mid-point of the coil is at ground potential. The reactance between one terminal of the coil and the work is then the characteristic impedance multiplied by the tangent of the electrical length of the semi-circumference. The total reactance is twice this value. That is,

$$X = 2Z_c\tan\left(\frac{2\pi}{\lambda}\frac{C}{2}\right) \cong \frac{2\pi CZ_c}{\lambda} = \frac{2\pi fZ_cC}{3\times10^{10}} \quad (35)$$

Thus we have at hand the necessary formulas for computing the efficiency, resistance, reactance, current and voltage. A casual inspection of these equations will reveal that the five conclusions reached early in the paper are sustained, within the limits of the restrictions placed on dimensions.



G. 16—Characteristic impedance of cylinder parallel to metal sheet

FIG. 17—A current transformer which is useful for inductive heating

Practical Example

The magnitude of values encountered when a single-turn coil is used will be shown by means of an example. The following constants will be used:

C = 15.0 cm
a = 0.24 cm
h = 0.44 cm
σ_c = conductivity of copper coil = 580,000 mhos for a cm cube
σ_m = conductivity of hot steel — 6000 mhos for a cm cube
μ_m = unity for steel above the Curie point
f = 10^6 cycles per second

From Eq. (32), we find that the efficiency is 84.2 percent. Substituting the numerical values in Eq. (33) gives a resistance of 0.0195 ohm, with a current of 226.0 amp for a power of 1000 watts.

Since a/h is 0.545, Fig. 16 gives 73 ohms for the characteristic impedance. Then Eq. (35) shows that the reactance is 0.23 ohm. This reactance multiplied by the current gives a voltage across the terminals of the coil of 52 volts.

The table gives a summary of this numerical data for a few values of h. It may be seen that increasing h results in a slight increase in the current to be handled and a sharp increase in the voltage appearing at

(*Continued on page* 382)

COMMENTS ON

Discussion of technical, economic and human considerations involved in high-fidelity sound reproduction for post-war radio receivers and broadcasting systems

By O. B. HANSON

Vice-President and Chief Engineer
National Broadcasting Company

THE term "high fidelity", as used at present in the general radio and sound reproduction field, has come to mean an extension of the audio range to the upper frequency limits of audibility of the human ear, as contrasted with a range limited to the usual 4000 or 5000 cycles. In reality, the term "high fidelity" is comparative, and it would be more correct to think of it as "higher fidelity".

Today there is available to the public a new system of program transmission, using frequency modulation of the very high frequency radio spectrum, where suitable channel spacing has been allocated by the FCC so that a wide audio band can be transmitted. In the interest of providing the public with a better radio broadcasting service, every advantage should be taken of frequency modulation toward establishing improved standards of transmission and reception. However, in determining these standards, it is quite important to take a practical view of what constitutes *realizable* high fidelity, bearing in mind that, in the overall result, various practical mechanical and electrical limitations, some physiological and psychological phenomena and, last but not least, the actual program content, are elements fully as important as a theoretically complete sound spectrum, or perhaps more so.

Fidelity implies a faithful reproduction of the original, a condition which in audio systems cannot actually be attained but, at best, only approached. True fidelity would require that:

1. The system not discriminate in any of its component parts against any frequency within the range under consideration.

2. No component part of the entire system introduce false harmonics.

3. There be no amplitude limitation of any portion of the spectrum in either transmission or reception.

4. The system be free from phase distortion.

5. The system be free from extraneous noise.

6. The loudspeaker and its driving amplifiers be capable of reproducing without distortion the full frequency range at loudness levels suitable for all listeners.

7. The acoustics of both the pick-up and listening spaces be suitable.

8. The spatial relationships of the sources of sound be transmitted and reproduced. This last probably requires some form of binaural or stereophonic system, neither of which is economically feasible for general public service at this time.

A system as described above, with the exception of binaural or stereophonic transmission, is not too difficult of realization from a transmitting standpoint. It might be closely approached in a receiver reproducing system, but the cost would probably be beyond the value which would be placed upon it by the purchasing public, particularly if the receiver were required to reproduce frequencies from 30 to 15,000 cycles.

Balanced Frequency Response

It is curious that the emphasis in general discussions of high fidelity thus far has been on an extension of the upper portion of the sound spectrum, and little has been said about the required balance between said upper portion and the lower frequencies. Actually it has been discerned on the basis of much observation that a balanced frequency response is quite essential to program enjoyment, although this balance factor has not yet been reduced to a rigorous mathematical formula. One authority has said, and our experience has confirmed this general statement, that the product of the lower and upper frequency limits should equal a number in the vicinity of 500,000. A simple example will show the approximate validity of this hypothesis as indicating the importance of balance. A system having frequency response limits of 50 to 8,000 cycles, or a total range of 7,950 cycles, is conceded as satisfactory by most authorities. If we retain this same range and compare it with a range of from 250 to 10,500 cycles, there is little question that the former is preferable for reasons of general "naturalness" but particularly because of the reproduction of a substantial range below 250 cycles. Note that with a range of 50 to 8000 cycles the bulk of program energy is in the band centering about a point at approximately 700 cycles.

Figure 1 shows preferred lower and upper frequency limits in which the balance is properly maintained. It will be noted that the product of the upper and lower frequency limits, as has been specified, is approximately 500,000. Many of the better home radio receivers of conventional type seem to fit surprisingly well within these frequency limits.

An extension of the frequency range to 17,000 cycles and down to 30 cycles would encompass the entire audible spectrum, but at only a small percentage of the total time would there be any appreciable en

HIGH FIDELITY

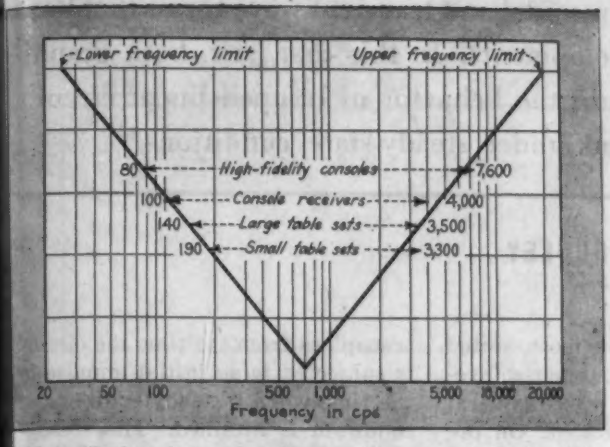


FIG. 1—Preferred lower and upper frequency limits for balanced frequency response in radio receivers. For any given receiver, the product of the lower and upper frequency limits should equal approximately 500,000

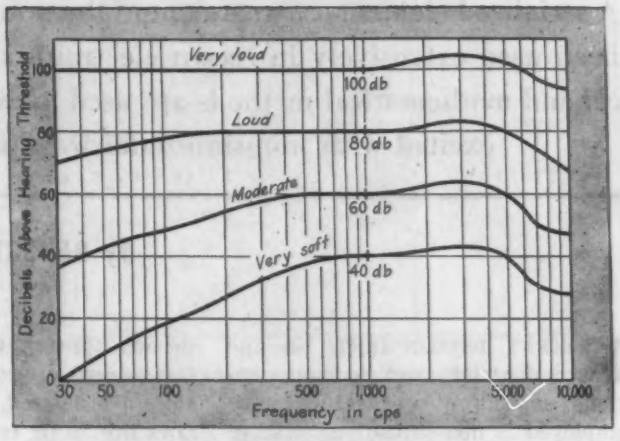


FIG. 2—Frequency response curves for normal ears at 20 years of age, for four different loudness levels at which radio receivers may be operated. At low levels, low-frequency sounds can barely be heard

ergy in the region above 10,000 cycles. Reproduction of frequencies above 10,000 cycles adds only to the enjoyment, if that is the word, of such things as key jingles, footsteps, handclapping and various extraneous noises (non-musical) from musical instruments, such as resin squeaks, air rush from wind instruments, and the like. These "sound effects" can hardly be considered essential or worth high cost to attain!

Tone Control Settings

Experience and various surveys have shown that, even when listeners have receivers capable of reproducing frequencies up to 5,000 cycles, they usually operate the tone control to restrict the audio range to an upper frequency cut-off somewhere between 2,500 and 4,000 cycles. Reasons given for this are that the "tone is mellower", "more pleasant", "less obtrusive", etc. Many listeners who are musically trained and who appreciate symphony and opera are, strangely enough, numbered in this class, indicating that this procedure does not stem from uncultivated tastes but has some other, more general, basis.

It has been claimed that, if distortion and noise were eliminated from the higher-frequency band, the public would then prefer the extended upper range. Perhaps so, if the higher range is properly balanced by adequate bass reproduction. Distortion and noise are unpleasant at any portion of the sound spectrum.

Present-Day Receivers

Receivers which at present provide millions of listeners with many hours of enjoyment seem generally adequate for reproducing the intelligence and entertainment contained in the program material. The witticisms of Charlie McCarthy, for example, are just as humorous on a receiver whose frequency range is 200 to 3,000 cycles as on a higher-fidelity system.

In this connection, it should not be overlooked that the entertainment and attention-engaging factors in musical listening are not concerned with quality alone. Such matters as appreciation of technique, melody itself, rhythm and the like, are of great importance to the musical ear and all these of course can be reproduced satisfactorily within a reasonably restricted frequency range.

The average radio listener purchases the table model receiver rather than the console. The former type of receiver cannot adequately reproduce bass frequencies, the fundamental reason being lack of sufficient physical size. It is only in the console type that adequate reproduction in the low-frequency range can be approached, but few even of this type have provided really good bass response free from noticeable cavity resonance. The higher frequencies, however, may be reproduced with properly designed smaller receivers, but generally at the expense of an undesirable directional characteristic. This varies with frequency in the preponderant majority of loudspeakers, so that reproduction of these higher frequencies is accentuated in front of the speaker and decreases with the increase in angle from the loudspeaker axis. The response at 45 deg is substantially less than optimum, even at frequencies as low as 3,000 cycles. A true higher-fidelity receiver must so distribute the higher frequencies that, within a specified solid angle, the response at all frequencies is substantially uniform.

Acoustic Limitations

The acoustic conditions of the studio and listening space can be controlled only over a frequency range of approximately 64 to 8,000 cycles, as design data and experience with materials and completed rooms is available only within those limits. At frequencies of 4,000 cycles and higher, the absorption

(*Continued on page* 385)

INTRODUCTION to

A serialized elementary treatment of the non-sinusoidal and transient wave forms that have been used extensively in recent electronic developments. In this first part, both graphical and mathematical methods are used to explain the behavior of lumped linear circuits excited with non-sinusoidal wave forms under steady-state conditions

By **BEVERLY DUDLEY**
Western Editor

RECENT DEVELOPMENTS in the industrial and communications aspects of electronics have employed non-sinusoidal wave forms and transients in greater and greater degree. Indeed, it would appear that the requirements of modern electrical technology have reached the stage where our concepts must be generalized and expanded beyond conventional alternating current theory to account for the behavior of circuits when subjected to periodic and non-periodic excitation of a wide variety of wave forms.

It will be the purpose of this series of articles to discuss, in elementary fashion, the behavior of a few simple electric circuits composed of linear elements (in which current is directly or inversely proportional to voltage for any frequency), where non-sinusoidal and transient voltages and current wave forms play an important role. An attempt will be made to outline electric circuit behavior under steady-state as well as transient conditions. To this end both mathematical and graphical methods will be employed. The mathematical approach appears to be most suited for use when exact numerical results are desired, or where general laws are to be formulated. On the other hand, graphical methods lend themselves quite admirably to an interpretation of some of the fundamental processes with which we must deal.

It is proposed to discuss three phases of the general topic: (1) the general voltage-current relations which exist for linear circuit elements and their applications to steady-state and transient non-sinusoidal wave forms, (2) a mathematical and graphical interpretation of the behavior of simple circuits, composed of linear elements, under steady-state conditions with non-sinusoidal wave forms, and (3) the analysis of simple circuits under transient conditions, with emphasis on the physical interpretation of the method of solving the circuit equations.

The combination of transient and steady-state conditions leads, of course, to the complete solution of the behavior of the electric circuit. The transient solution represents that phase of circuit behavior which transpires from the time the circuit is subjected to an initial impulse to the time when a steady equilibrium condition is attained. The steady-state condition is that equilibrium state of affairs which exists after the transient "cushion" has decayed to a negligibly small magnitude.

TABLE I—Voltage-Current Relations for Linear Circuit Elements

Circuit Element	Voltage Equation	Current Equation
Resistance, R	$e_R = Ri_R$	$i_R = \frac{e_R}{R}$
Self-Inductance, L	$e_L = L\frac{di_L}{dt}$	$i_L = \frac{1}{L}\int e_L\,dt$
Capacitance, C	$e_C = \frac{1}{C}\int i_C dt$	$i_C = C\frac{de_C}{dt}$

Fundamentals of Circuit Behavior

The fundamentals of linear electric circuit theory are equally applicable to transient or steady-state conditions. With emphasis placed on the physical interpretation, those fundamental concepts which will be employed may be stated as follows:

(1) The instantaneous voltage across a resistor is equal to the product of its resistance in ohms and the instantaneous value of the current in amperes flowing through it.

(2) The instantaneous value of the voltage drop across an inductor is equal to the product of its inductance in henries and the time rate of change of the current flowing through it in amperes per second.

(3) The instantaneous value of the current flowing through a capacitor is equal to the product of its capacitance in farads and the time rate of change of the voltage across its electrodes in volts per second.

(4) A magnetic field surrounding an inductor is produced when an electric current flows through it.

(5) An electric field is established between the two conductors of a capacitor when a difference of potential exists between them.

(6) A finite amount of time is required to establish an electric or a magnetic field.

TRANSIENTS...Part I

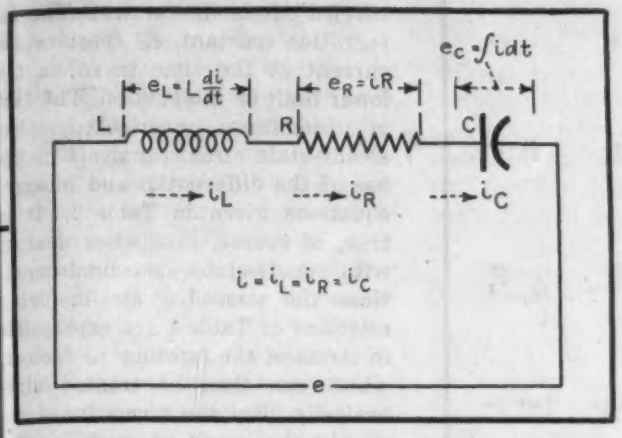


FIG. 1—General type of series circuit consisting of linear elements *R, L, and C*

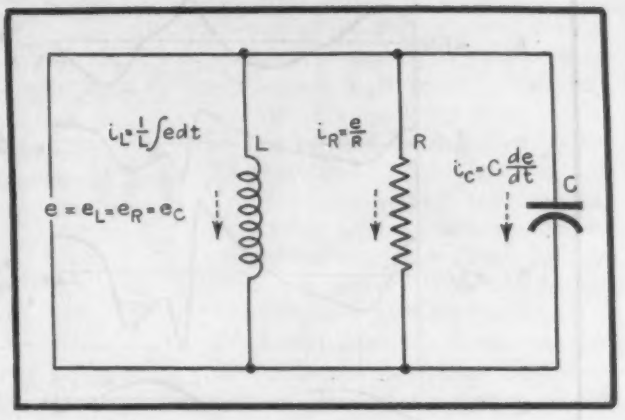


FIG. 2—General type of parallel circuit composed of linear elements *R, L, and C*

(7) The superposition theorem may be applied to circuits composed of linear circuit elements, that is, to circuit elements whose properties are independent of the voltage across or the current through them. The superposition theorem states that in a network composed of linear circuit elements, each electromotive force produces a current independent of any other electromotive force, the electromotive forces and currents of which may be added algebraically to obtain the resultant. The ability to superpose currents and voltages of a given frequency, independently of those of other frequency and of transients, is a direct consequence of the restriction that only linear circuit elements are under discussion. The superposition theorem does not apply (at least, not without extension) to non-linear elements.

(8) For circuits employing series connections, Kirchhoff's voltage law applies. This law states that the total voltage drop across an electric circuit is equal to the sum of the voltage drops across each of its circuit elements, and is equal to the sum of the voltage rises or impressed electromotive forces.

(9) For circuits employing parallel connections, Kirchhoff's current law is valid. This law states that the current flowing to any juncture is equal to the sum of the currents flowing away from the juncture. (It may be noted that both forms of Kirchhoff's laws are merely specialized forms of conservation of energy.)

The first three of these statements relates the voltage and current for the three different linear circuit elements, all of which are assumed to be ideal. An ideal circuit element is one which is presumed to behave physically in strict accordance with the mathematical prediction of its behavior; all losses are assumed to be zero (except the resistance of a resistor) and distributed capacitance, inductance and resistance are assumed absent.

When expressed in mathematical form, the first three statements (and their inverse) give rise to the six equations of Table I. The voltage-current relations expressed by these six equations are derivable not only from experimental observation but also from definitions of fundamental electrical concepts. All six relations are of paramount importance to the study of linear circuit behavior. However, the mathematical expressions in one column are merely alternative forms of the equations in the other, so there are only three, instead of six independent relations. When dealing with voltages and currents in *L* and *C* elements, we are involved not only in algebraic operations, but in rates of change and inverse rates of change, treated, respectively, in differential and integral calculus. Calculus, dealing with quantities which vary, introduces mental concepts which may be difficult to grasp at first, just as it might be difficult to play, at first, a ball game in which the number of players is constantly varying. While no one can hope to be completely free to carry out independent thinking on electric circuits who does not have at least a rudimentary knowledge of elementary calculus, it is the aim here to present the fundamental concepts in graphical form so that a formal acquaintance with this branch of mathematics may be dispensed with.

We may obtain experimental verification of the relation given in Table I. However, since it is not possible to obtain ideal circuit elements, no experimental verification can be more than an approximation to the ideal state of affairs. The approximation may be exceedingly good, and with well-designed circuit elements it will be good. However, it can be shown that the voltage-current relations of Table I have a true theoretical foundation.

Derivation of Voltage-Current Relations

From a study of elementary electricity, the charge (the number of electrons or ions) on a capacitor q is proportional to the product of the voltage e between the capacitor plates and the capacitance C of the capacitor. Quantitatively, this yields the result

$$q = eC \qquad (1)$$

Since charged particles are the fundamental building-blocks of electricity, all electrical effects are explainable in terms of them, as for instance, the concept of an electric

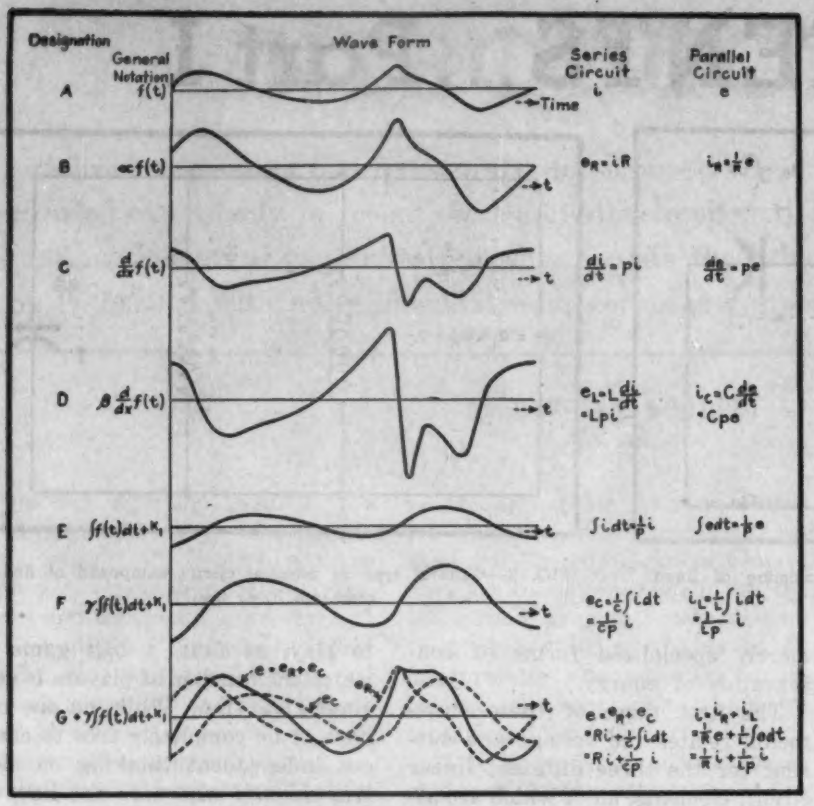


FIG. 3—General type of wave form impressed on a series or parallel *RLC* circuit (curve A) and resulting wave forms existing in other portions of the circuit

current. From the study of the flow of an electric current, we learn that an electric current is the time rate of change of charge. Expressed analytically we have the result

$$i = dq/dt \qquad (2)$$

If we substitute the first of these equations into the second, and keep in mind that C is a constant (since we are dealing with circuit elements which are constants) the current can be expressed in terms of the capacitance and the voltage by means of the equation

$$i = \frac{dq}{dt} = \frac{d}{dt}(eC) = e\frac{dC}{dt} + C\frac{de}{dt}$$

$$= 0 + C\frac{de}{dt} = C\frac{de}{dt} \qquad (3)$$

If we multiply this equation through by dt, divide by C, and integrate both sides of the resultant equation, the voltage across a capacitor is expressed in terms of the current through it by means of the equation

$$e_C = \frac{1}{C}\int i\,dt + K_C \qquad (4)$$

The constant K_C is required to account for any residual charge which may appear on the capacitor at the time for which $t = 0$.

Similarly we may develop analytical reasoning to support the equation connecting voltage and current in an inductive circuit. From the laws of electromagnetism, the voltage is related to the magnetic flux by means of the experimental result stating that the voltage is proportional to the number of turns, and also to the time rate of change of flux. The total flux is the product of the number of turns, N, assumed to be constant, and the flux, ϕ, per turn. The total flux $N\phi$ is produced by the current, i, and the resultant voltage may be written in the form

$$e_L = \frac{d}{dt}(N\phi) = N\frac{d\phi}{dt} + \phi\frac{dN}{dt}$$

$$= N\frac{d\phi}{di}\frac{di}{dt} + 0 = L\frac{di}{dt} \qquad (5)$$

The last is permissible since the inductance, L, is defined as the flux linkages per unit time or the number of turns times the derivative of the flux with respect to the current, or $L = Nd\phi/dt$. Again, multiplying by dt, dividing by L and integrating both sides of the equation we obtain the result

$$i = \frac{1}{L}\int e\,dt + K_L \qquad (6)$$

Using the results of Table I and Kirchhoff's law we can build up general analytical expressions which support (and in fact are essentially the same thing as) the graphical evaluation of wave forms which are carried out in this article. The integration constant, K_L specifies the current at the time taken as the lower limit of integration. The fact is sometimes overlooked that steady-state circuit analysis makes use of the differential and integral equations given in Table I. It is true, of course, that when dealing with steady-state sinusoidal conditions the somewhat awe-inspiring relations of Table I are expressible in terms of the familiar $j\omega$ factors, which can then be treated algebraically. But the terms in $j\omega$ are merely the result of applying the more general equations of Table I to a special case; when we no longer deal with a fortuitious special case, we must revert to thinking in terms of fundamentals. These fundamentals involve time rates of change (and their inverse), and since these change for each new type of wave form, they also involve a completely new solution of the circuit relations. Essentially, the same kind of generalization is carried out when we proceed from sine-wave to non-sinusoidal wave forms as is involved when we make the jump from d-c to a-c theory.

Voltage-Current Relations Hold For Transient and Steady-State Conditions

The fundamental voltage-current relations given in Table I are completely general for linear circuit elements, and therefore may be applied to steady-state and transient currents and voltages of any physical realizable wave shape. Before we may proceed it is necessary to build up a thorough understanding of these voltage-current relations. This could be done by discussing, individually, the voltage-current relations of each separate circuit element, and subsequently applying this reasoning to circuits composed of various combinations of circuit elements. We may combine both of these steps, and study the voltage-current relations of the various elements when combined in series or parallel circuits.

In the analysis of series circuits, it will be convenient to assume the current of specified wave form and then ascertain the magnitude and

wave forms of the voltage drops across each of the circuit elements as well as that of the impressed voltage. The voltage across each of the circuit elements is determined in terms of the equations given in the third column of Table I. By Kirchhoff's voltage law the impressed voltage will be equal to the sum of the voltage drops around the circuit. Such an analysis (in which the current is regarded as the independent variable) may be carried out for any combination of the three fundamental circuit elements connected in series. Likewise, for parallel circuits composed of any combination of the three circuit elements, the magnitudes and wave forms of the impressed voltage will be assumed and the magnitudes and wave forms of the total and branch currents will be required.

Series Circuit

Consider the circuit of Fig. 1 composed of R, L, and C in series and in which a current, i, flows as a result of an impressed electromotive force, e. For this case, Kirchhoff's current law takes the form

$$i = i_L = i_R = i_C \qquad (7)$$

The voltage law becomes

$$e = e_L + e_R + e_C = L\frac{di}{dt} + Ri + \frac{1}{C}\int i\,dt \qquad (8)$$

By means of the second circuit equation, the steady-state voltage drops across portions of the circuit can be determined as soon as the magnitude and wave form of the current flowing through it are known. Since the voltage across a constant resistance is proportional to the current through it, the current and voltage wave forms for a resistance will be identical functions of time.

The voltage-current relations for inductance and capacitance are expressed by more complicated equations and dissimilarity of current and voltage wave forms may therefore be anticipated. In general, for each different wave form of current flowing through the series circuit we may expect completely dissim-

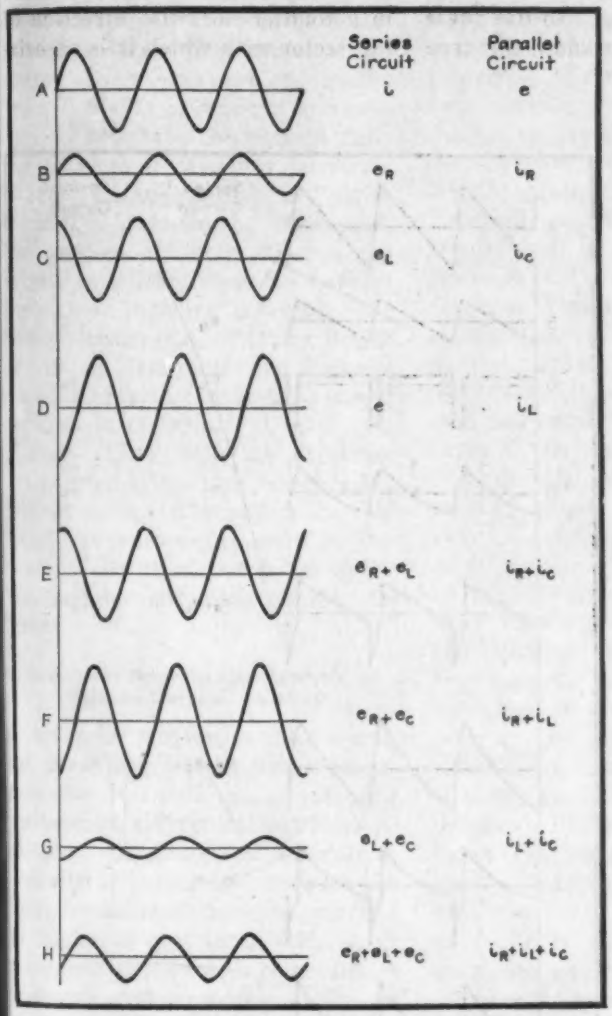


FIG. 4—Current and voltage wave forms in series and parallel circuits with sinusoidal excitation. As applied to series circuits the significance of the curves is as follows: (A) Current through circuit; (B) Voltage across R; (C) Voltage across L; (D) Voltage across C; (E) Voltage across R and L; (F) Voltage across R and C; (G) Voltage across L and C; (H) Voltage across R, L, and C. All wave forms have the same frequency and sinusoidal type of variation, but differ in amplitude and phase

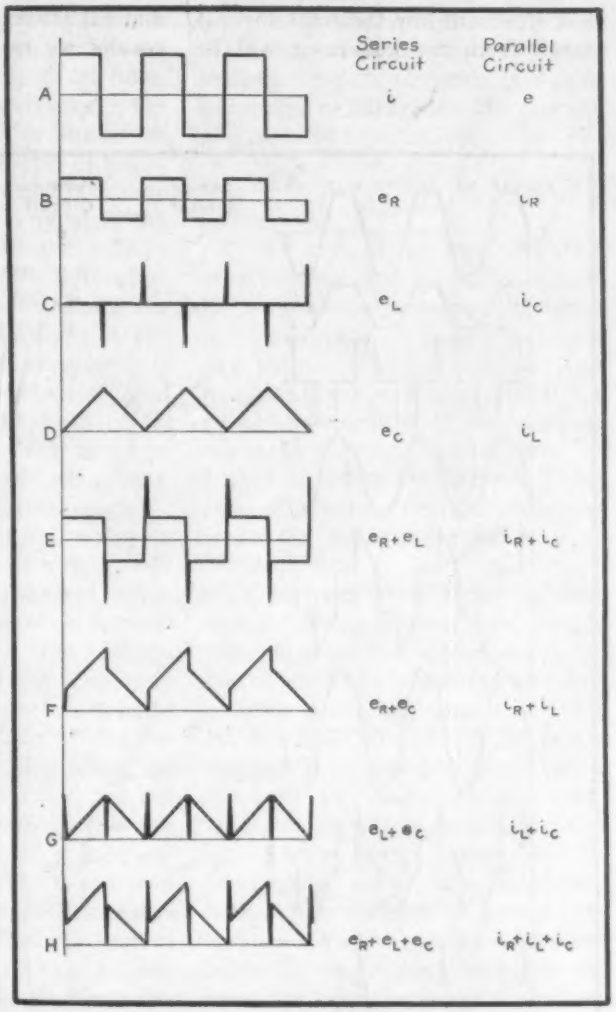


FIG. 5—Current and voltage wave forms in linear circuits with square wave excitation. As applied to parallel circuits, the curves have the following significance: (A) Impressed voltage; (B) Current through R; (C) Current through C; (D) Current through L; (E) Current through R and C; (F) Current through R and L; (G) Current through L and C; (H) Current through R, L, and C connected in parallel. The only wave form resembling the impressed excitation is that for R

ilar wave forms of voltage across the circuit as a whole as well as across L and C. Indeed, when we come to consider the matter carefully it would appear quite remarkable that we should ever obtain voltage drops across different kinds of circuit elements, whose wave forms were similar to one another or (except in the case of the resistance) similar to that of the current flowing through the circuit.

Parallel Circuit

Next consider the general parallel circuit of Fig. 2 composed of the three different circuit elements, L, R, and C in parallel, across which an electromotive force, e, is applied. From Kirchhoff's voltage law, the voltage drop across each circuit element is equal while from Kirchhoff's current law the total current taken from the generator will be equal to the sum of the three branch currents. Making use of the circuit relations of Table I, Kirchhoff's laws may be expressed quantitatively in the form

$$e = e_C = e_R = e_L \qquad (9)$$

for the voltages and in the form

$$i = i_C + i_R + i_L = C\frac{de}{dt} + \frac{e}{R} + \frac{1}{L}\int e\,dt \qquad (10)$$

for the currents. While the physical interpretation of Eq. (8) is different from that of Eq. (10) the forms of the two equations are identical. The two circuits for which differential equations of the same form exist are said to be duals.

Although representing exceedingly important electric circuit relations, Eq. (8) and (10) can be regarded thus far merely as mathematical abstractions. To use these results we need to know the true significance and physical interpretation of the mathematical expressions di/dt, $\int i\,dt$, de/dt, and $\int e\,dt$ which are associated with varying values of current and voltage. This is especially important since these symbols do not represent algebraic quantities, in the usual sense of the word, but designate types of operations which must be carried out. They are directives, if you will, telling us how we must perform a particular job in order that a desired end result may be achieved. The symbolic notation, di/dt, indicates that we are to carry out the operation of differentiating the current, i, with respect to time, t. The notation $\int i\,dt$ calls for the process of integrating the current i with respect to time t, just as the symbol j calls for a 90-degree rotation in a counter-clockwise direction of the vector with which it is associa-

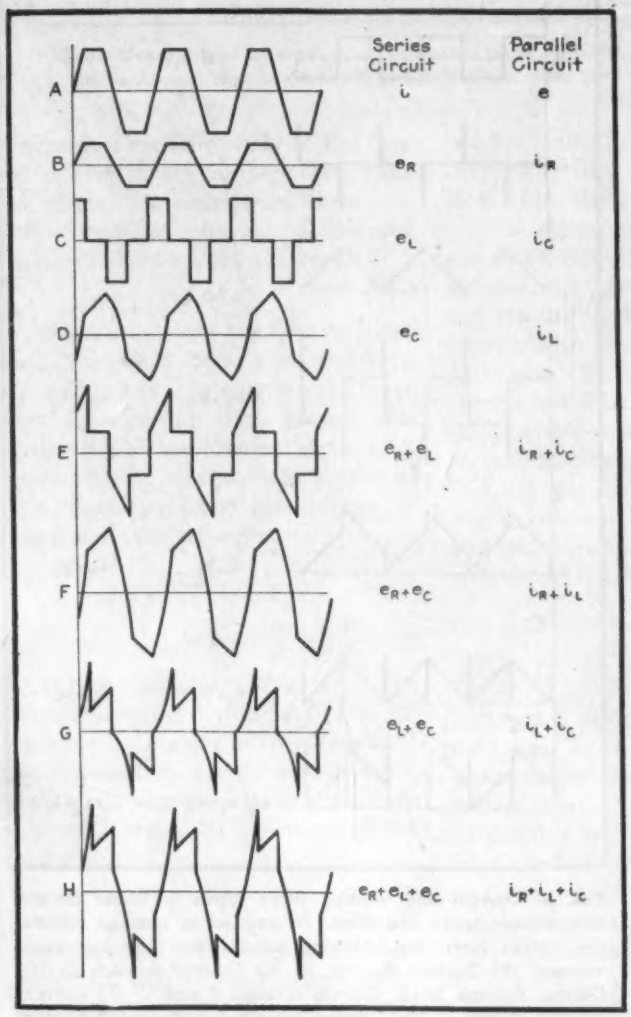


FIG. 6—Current and voltage wave forms for series and parallel *RLC* circuits with trapezoidal wave form excitation

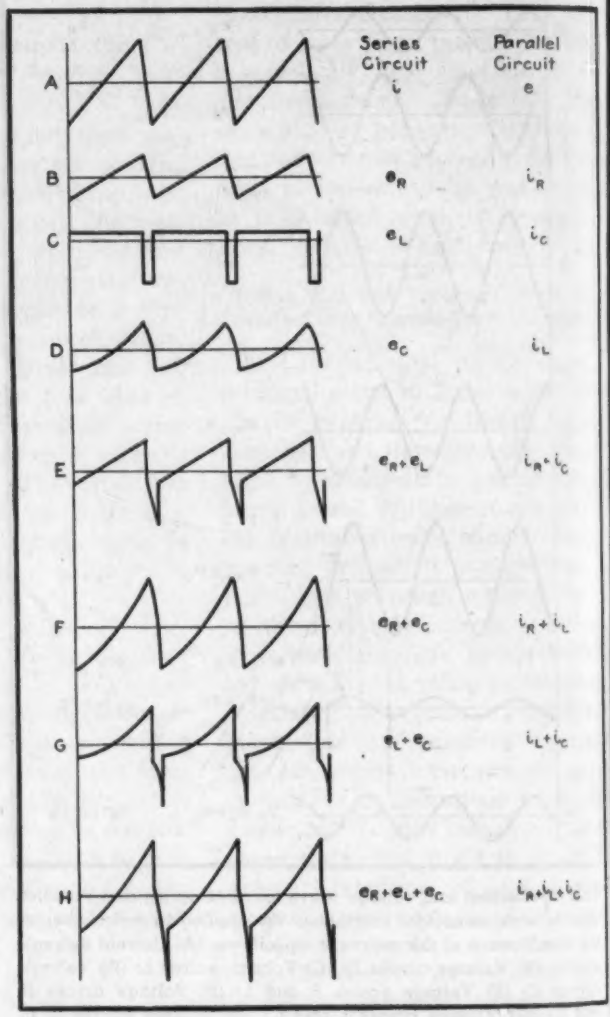


FIG. 7—Current and voltage wave forms for series and parallel *RLC* circuits with triangular wave form excitation

ted. It should be noted that differentiation, indicated by the notation di/dt, and integration, indicated by the notation, $\int i\,dt$, are inverse operations just as are those of squaring and extracting a root.

Since the derivative commonly takes the form of a time rate of change, the corresponding integral may be regarded as the inverse time rate of change. Graphically, rates of change are indicated by the slope of a graphical plot, while integrals are represented by areas under a curve. The fundamental concepts involved in differentiation and integration are really quite simple, but a slight detour will be in order to review the physical interpretations underlying these mathematical operations.

The process of differentiation is involved when we desire to determine the voltage drop across an inductor whose current is known ($e_l = L\,di/dt$) or when it is necessary to ascertain the current flowing through a capacitor in terms of the voltage across its plates ($i_c = C\,de/dt$). On the other hand, the process of integration is involved in determining the current through an inductor in terms of the voltage across it, $i_L = (1/L)\int e\,dt$, or in determining the voltage across a capacitor when the current through it is known: $e_c = (1/C)\int i\,dt$. Thus, both the processes of differentiation and integration are not mere mathematical abstractions, but represent exceedingly important conditions of behavior of the various electrical circuit elements.

Graphical Approach to Analysis of Voltage-Current Relations

A formal treatment of the process of differentiation and integration may be found in any standard textbook on differential and integral calculus. A graphical interpretation will be substituted here for the more formal mathematical approach in the belief that in an elementary treatment this procedure results in a clearer understanding of the essential physical principles. The mathematical operations will be interpreted in terms of electric circuit behavior.

Suppose that time-varying curve A of Fig. 3, $f(t)$, represents the wave form of current flowing in the series circuit of Fig. 1 or the voltage across the parallel circuit of Fig. 2. The following analysis can be carried out for either type of circuit, according to the relations given at the right of this diagram. To be specific, we shall apply the analysis to the series circuit of Fig. 1. Since $e = iR$ (where R is a constant) the voltage across the resistor will be exactly of the same wave shape (except for scale factor of the ordinates) as that of the current. Hence it may be represented by curve B.

Wave Form of Voltage Drop Across Inductor

With the current wave form as shown at A in Fig. 3 it will be necessary to differentiate this current and multiply it by the inductance L to obtain the voltage across the inductor through which the current flows. Graphically it is therefore necessary to determine the derivative (or slope) of the given current wave (represented by curve A) to obtain the rate of change (curve B) and then to multiply the result by L to obtain the voltage across L (curve C). The derivative of curve A at any point along the t axis is given by its slope at the point in question. Accordingly, if we measure the slope of curve A at each point and plot, as ordinates in curve C, the magnitudes of these slope determinations at the corresponding values of t, the resultant curve, C, will be the derivative of curve A. The derived curve, C, will be positive (above the zero axis) when the slope of curve A is positive—that is, when a line tangent to the curve runs from the lower left-hand to the upper right-hand region. The magnitude of the derived curve will be zero when the slope of the original curve is zero or when a line drawn tangent to the curve (at the value of t in question) is horizontal. The magnitude of the derived curve will increase as the slope of the original curve increases and vice versa. A little study will show the relation existing between the original curve, A, and the derived curve, C. The reader will understand, of course, that the graphical operations are merely representations, or ways of indicating, the fundamental physical phenomena taking place.

The absolute value of the voltage across the inductor is obtainable by multiplying the time rate of change of current, represented by the derived curve C by a suitable constant, L, equal to the inductance of the circuit. If the ordinates of curve C are multiplied by L, curve D will now represent the wave form of the voltage across an inductance.

To ascertain the voltage across a capacitor through which a known current flows, it is necessary to integrate the current and divide by the capacitance, C. If the current is represented graphically by curve A, then the integral of the current may be represented graphically by the area under the current curve (A), as is shown in any text on integral calculus. This area represents what we have chosen to call the inverse rate of change. To illustrate the fundamentals, it is now necessary to carry out the process of graphical integration.

Wave Form of Voltage Across Capacitor

If we plot, point by point, the area inclosed between curve A and its zero axis, the resultant curve will be as shown at E in Fig. 3. At any point along the abscissa, the height of curve E represents the area under curve A. The integrated curve, E, increases as the area of curve A above the zero axis increases, whereas curve C decreases when the area under curve B is negative.

In deriving curve E as the area under the original curve A, a certain amount of arbitrariness is involved until the beginning and end points are specified on the original curve whose area is to be ascertained. These end points are called the limits of integration. The arbitrariness resulting from failure to specify the limits between which the original curve A is integrated, makes it necessary, in general, to add a constant, K_1, to the integrated curve F. In the graphical plot, the need for inserting such a constant was not apparent since we began finding the area under the curve at a specific point, $t = 0$, thus establishing one limit of integration. The other constant of integration is that value of t for which the process is discontinued. For purposes

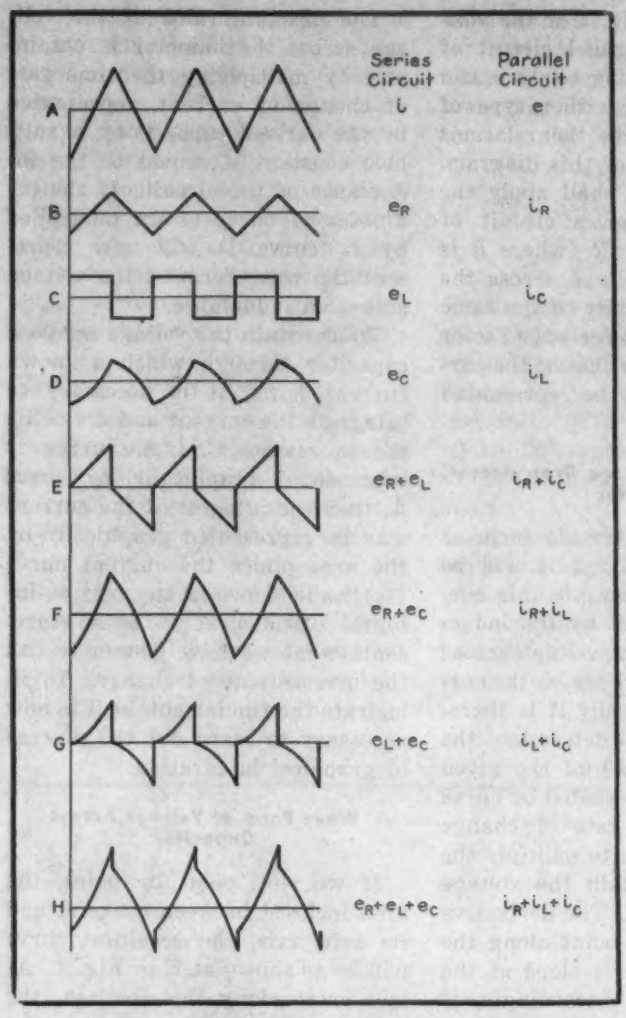


FIG. 8—Current and voltage wave forms for series and parallel *RLC* circuits with saw-tooth wave form excitation. This wave form is used extensively in sweep circuits of cathode-ray tubes used in television transmitters, television receivers, oscilloscopes and newly-developed cathode-ray equipment

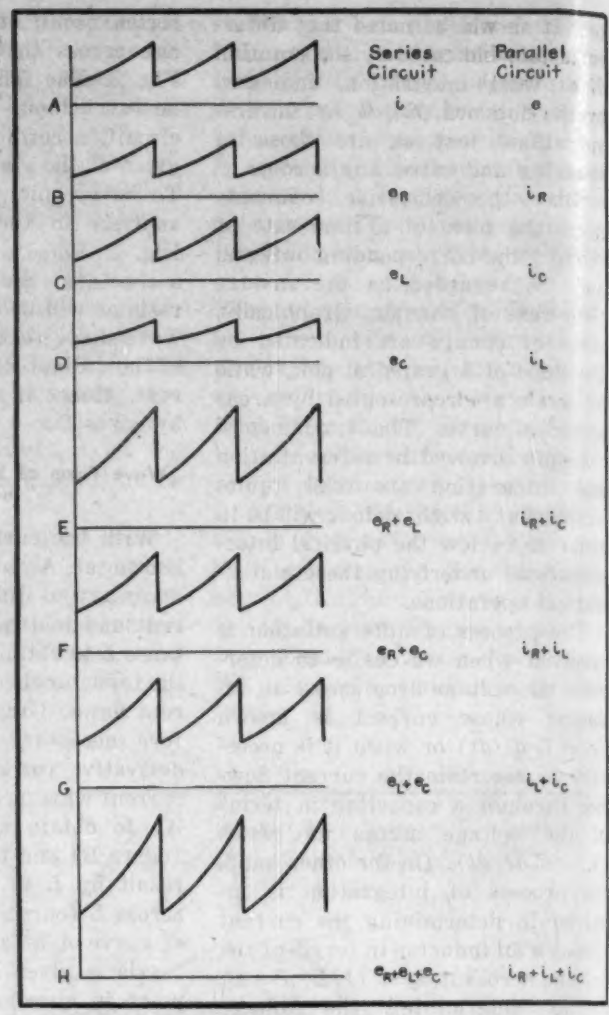


FIG. 9—Current and voltage wave forms for series and parallel *RLC* circuits with excitation which is a recurrent portion of an exponential wave form. All wave forms are identical except for amplitude, because the exponential function has the same shape as its derivative and integral

of generality the integration constant, K_1, has been retained in the column marked General Notation. Physically, the integration constant represents the voltage across the capacitor (for the series circuit) or the current in an inductor (for the parallel circuit) when $t = 0$. If we assume, as we shall, that the voltages and currents are initially 0, the constant may be dropped. This has been done in writing the electrical equations at the right of the wave form diagrams.

In obtaining the derivative or the integral of the given time-varying function, we have carried out an operation of inversion on the original function representing the given current. In obtaining the derivative of the current this inversion has been obtained by means of the operator, di/dt, whereas the operator $\int i\,dt$ has been used in obtaining the integral curve of the current. The mathematical directives which indicate how these conversions are to be made are called inversion operators.

Inversion Operators

We have now illustrated, by graphical methods, the inversion of wave forms by means of the inversion operators, $df(t)/dt$ and $\int f(t)dt$, and it is now necessary to apply Kirchhoff's laws to solve the voltage-current relations for simple circuits. Consider, for example, a series circuit composed of R and C or a parallel circuit composed of R and L, the necessary voltage and current conditions of which are shown by curves B and F. By adding curves B and F graphically, we carry out the necessary algebraic operations required by Kirchhoff's law. Thus, the full line of curve G (representing the algebraic sum of curves B and F) represents the wave form of voltage across an RC series circuit or the wave form of current for a circuit of R and L in parallel. The curves are lettered to apply only to a series RC circuit. The graphical addition is in accordance with the superposition theorem.

It will be observed that all of the curves of Fig. 3 are single-valued functions of time, without discontinuities. A single-valued function of time is, of course, some relation having a single value at any given instant, and a continuous function is one having no breaks or discontinuities. Since we have chosen a perfectly arbitrary function for purposes of discussion, the general

procedure which has been developed is applicable to sinusoidal wave forms which may be encountered in practice, since these are single-valued and continuous. In general, these conditions will be fulfilled in practice.

Graphical Method Applied to Sinusoidal Waves

We shall apply the method outlined above to an analysis of the familiar sinusoidal time variations as the first application of the graphical procedure. Since there exists a dual relation between the series and parallel RLC circuits, it will be necessary to analyze only one such circuit. For purposes of illustration, the series circuit will be treated.

The voltage-current relations existing in series RLC circuit are given by Eq. (7) and (8). For the particular application in question, a sinusoidal current is assumed so that the instantaneous value of the current may be expressed graphically by curve A of Fig. 4 or mathematically as

$$i = I_m \sin \omega t \qquad (9)$$

By inserting Eq. (9) into Eq. (8), the impressed voltage and the voltage drops will be given by

$$e = e_L + e_R + e_C = L\frac{d}{dt}(I_m \sin \omega t) + RI_m \sin \omega t + \frac{1}{C}\int I_m \sin \omega t\, dt \qquad (10)$$

Since the voltage drop across the resistor is proportional to the current through it, we have immediately

$$e_R = RI_m \sin \omega t \qquad (11)$$

Graphically this voltage drop is obtained by multiplying curve A of Fig. 4 by R to obtain curve B. For the remaining voltage drops we must now differentiate and integrate the sine function in order to make use of Eq. (10).

Since the derivative of the given time-varying (sine) function is its slope—or its time rate of change—it is evident that the derivative will be proportional to the frequency or to $\omega = 2\pi f$ since the slope varies cyclically with frequency. Therefore ω will be a multiplying factor. It is also evident that within any cycle, or period, the time rate of change is equal to the slope of the given curve. Now the slope of the sine curve yields a cosine curve. Therefore, the derivative of the sinusoidal current is curve

$$\frac{di}{dt} = \frac{d}{dt}(I_m \sin \omega t) = \omega I_m \cos \omega t$$

$$= \omega I_m \sin\left(\omega t + \frac{\pi}{2}\right) = j\omega I_m \sin \omega t = j\omega i \qquad (12)$$

The third step in the above equation is justified since there is a 90-deg phase shift between the sine and cosine function. We may indicate this 90-deg phase shift by the added angle, $\pi/2$ radians, or by any other generally accepted notation which will be understood as indicating a 90-deg phase shift. Such a device is the operator j. Accordingly we may multiply the final results by j (instead of adding the angle $\pi/2$) to indicate the desired shift. By means of this artifice we have achieved the very important advantage of being able to express the voltage across the inductance as a sine function (instead of a cosine function) which is also the expression used to designate the time variation of current. The voltage across the inductance is

$$e_L = L\frac{di}{dt} = j\omega L I_m \sin \omega t = j\omega L i \qquad (13)$$

obtained by multiplying the final form of Eq. (12) by L. The result is shown graphically as curve C of Fig. 4. It will be noted from Eq. (12) and (13) that for a-c theory involving sine waves, the inversion operator, di/dt, can be replaced with the expression $j\omega$.

The graphical and geometric significance of the integral of a sine wave is slightly more difficult. Since the integral is represented graphically by the area under the given curve, the area under the curve, for each full cycle or period, will decrease as the time interval of the period decreases, or as the frequency increases. The inverse time rate of change is inversely proportional to frequency, just as the time rate of change was found to be proportional to frequency. Thus the integral is inversely proportional to $\omega = 2\pi f$, or is proportional to $1/\omega = 1/2\pi f$. Also, within any cycle or period the integral is proportional to the negative of the cosine wave. Hence we have the result

$$\int i\, dt = \int (I_m \sin \omega t)\, dt = -\frac{1}{\omega} I_m \cos \omega t$$

$$= -\frac{I_m}{\omega}\sin\left(\omega t - \frac{\pi}{2}\right) = -j\frac{I_m}{\omega}\sin \omega t$$

$$= -j\frac{i}{\omega} \qquad (14)$$

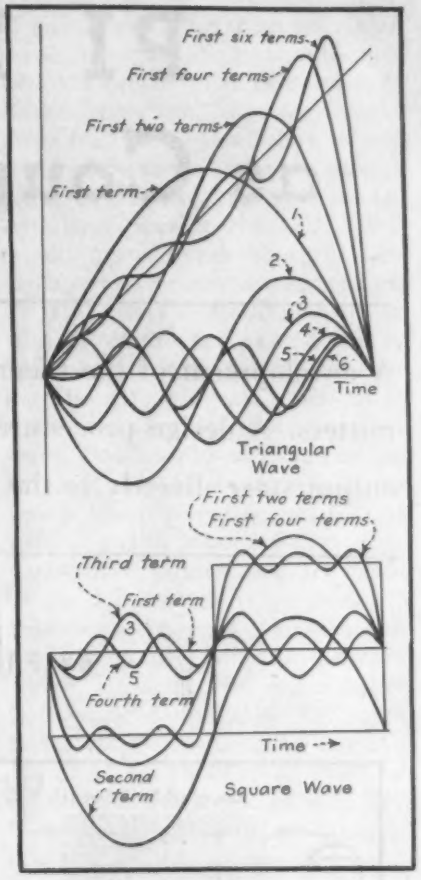


FIG. 10—Two diagrams illustrating the manner in which recurrent wave forms may be constructed from a series of sine waves of appropriate amplitude, frequency and phase. The order of the harmonics is indicated by the numerals. Successive stages in the early development of the desired waves are shown

The justification of the $-j$ is based upon the same reasoning as that already described above. The voltage across the capacitor is

$$e_C = -j\frac{I_m}{\omega C}\sin \omega t = -j\frac{1}{\omega C} i \qquad (15)$$

obtained by multiplying Eq. (14) by $1/C$. Again, through the use of the j operator we have been able to express the voltage drop across the capacitor in terms of a sine curve which is used to express the time variation of current.

Using Eq. (11), (13) and (14) and Kirchhoff's voltage law,

$$e = j\omega L I_m \sin \omega t + RI_m \sin \omega t - j\frac{1}{\omega C} I_m \sin \omega t$$

$$= \left(j\omega L + R - j\frac{1}{\omega C}\right) I_m \sin \omega t$$

$$= \left(j\omega L + R - j\frac{1}{\omega C}\right) i \qquad (16)$$

Since L, R, and C are constants, this equation shows that the instantaneous value of the impressed volt-

(*Continued on page 392*)

PI NETWORKS as Coupled Tank Circuits

A development of the theory of pi networks as they apply to r-f output circuits of transmitters. A design procedure is outlined and curves are given to simplify matching the output stage directly to the transmission line or antenna, without an output transformer

By FREDERIC D. SCHOTTLAND *Consultant Forest Hills, N. Y.*

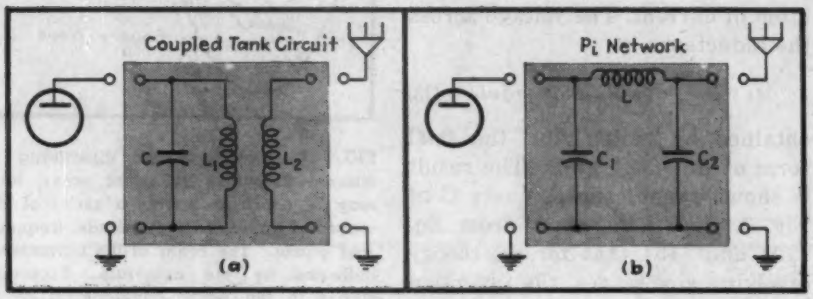


FIG. 1—Simplified representation of a class C r-f output stage feeding a transmission line or antenna at resonance through a coupled tank circuit (a) and through an equivalent pi network (b)

THE use of a π configuration of reactances to couple a class C power amplifier to its load is not new. However, the proper handling of such a network in this application is far from being common knowledge to engineers who design or operate transmitting equipment. This lack of knowledge generally results in a circuit containing few of the obtainable advantages, and one whose harmonic attenuation leaves much to be desired.

New Approach Needed

Unfortunately for the transmitter engineer, design information on π networks is to be found principally in texts concerning themselves with filter and transmission-line theory. As a consequence, the subject is not approached in such a manner as to apply directly to the problem at hand. When following the customary design procedure, an infinite number of solutions are indicated. Cut-and-try methods of adjustment are extremely laborious, and modifications appear to give totally uncorrelated results. The underlying theory as presented in texts is in such form as to give little help, since the means for imposing the further conditions necessary to obtain the single desired solution are by no means apparent.

If the π network is to replace the coupled tank circuit, obviously it must perform the same functions. In general, the basic requirements of the circuit are:

1. It must transform the load to some predetermined impedance.
2. It must deliver a prescribed amount of energy at some maximum or required efficiency.
3. It must provide a preselected degree of harmonic attenuation.

Review of Matching Problem

Figure 1(a) is a simplified schematic of a vacuum tube coupled through a plate-tuned transformer to a load which may be an antenna at resonance or a properly terminated transmission line. Figure 1(b) accomplishes the same coupling through the use of a π network. Both will perform the functions listed above.

In the coupled tank circuit of Fig. 1(a), the first function is controlled by correctly choosing the turns ratio of L_1 and L_2 and the amount of mutual inductance. The second function is accomplished by having the proper ratio of L_1 to C. Finally, we obtain sufficient harmonic attenuation by keeping the circuit above some minimum value of Q. In other words, we couple in a resistance with a definite relationship to either reactance. All of these points are well covered in existing literature, and this knowledge is basic to the transmitter engineer.

Inspection of the π network of Fig. 1(b) does not immediately re-

veal how all this is accomplished. We know that a π network will transform impedances and act as a coupling device, but how to control the efficiency and the Q of the circuit is not indicated, nor is this design information available in convenient form.

Reduction of π to L

In any actual circuit we are not concerned with the internal impedance of our tube as such, but rather with the impedance into which it must work. As a limiting case it becomes that impedance which will give the maximum transfer of radio-frequency power under the specific operating conditions of grid bias, excitation and plate voltage employed, without exceeding the rated plate dissipation of the tube. In the circuit of Fig. 2, therefore, R_G will be taken to mean the impedance with which we wish to terminate our generator, and not the internal impedance of the generator itself.

The values of X_T and X_C to match R_A to R_G are obtained from the relations*

$$X_T = \frac{-R_G X_L}{R_G \pm \sqrt{R_G R_A - X_L^2}} \quad (1)$$

$$X_C = \frac{-R_A X_L}{R_A \pm \sqrt{R_G R_A - X_L^2}} \quad (2)$$

To avoid an imaginary value for X_T or X_C,

$$X_L^2 \leq R_G R_A \quad (3)$$

To make X_C infinite in value so the output capacitor will drop out, we must choose the negative sign for the radical and use a value of R_G such that

$$R_A = \sqrt{R_G R_A - X_L^2} \quad (4)$$

This in no way changes the performance of the network, but the circuit simplifies to the L network of Fig. 3, which may be more easily analyzed.

The L network shown in Fig. 3 is of extreme interest. It is not only the equivalent circuit of a π network, but if R_A is taken as the reflected resistance of the load, it is the equivalent circuit of a coupled tank network as well. Here, then, is common ground and a means of correlating the two circuits. At resonance, X_T is equal to X_L. R_G was defined as the impedance into which we are to work. That is, it is the image impedance of the network, so

$$X_L = X_T = R_G/Q \quad (5)$$

$$R_A = X_L/Q \quad (6)$$

From Eq. (5), at any desired Q the value of X_L is fixed, and consequently the value of X_T is also fixed. The value of R_A is given by Eq. (6). From Eq. (5) and (6) we see that

$$R_G = X_L^2/R_A \quad (7)$$

Limitations of L Network

We formerly intended to find a network which would match R_G to whatever antenna we had. Because of the restriction of Eq. (4), however, we must now match our antenna to our network. This by no means destroys the usefulness of the network, for the value of R_A which has been obtained is the minimum impedance into which we may work under the given operating conditions. This minimum is entirely independent of the restrictions of Eq. (4).

If the actual load has an impedance greater than R_A it can be made to look like R_A so far as its resistance is concerned, by shunting it with the proper value of reactance. Naturally we shall choose a capacitance for this purpose, since it will act to increase the harmonic attenuation. If the actual antenna has an impedance smaller than R_A, there is nothing we can do about it. Obviously, to increase the impedance we must insert a reactance in series with R_A. If this is a capacitance, it will subtract from X_L, and if an inductance it will add. We may, therefore, view the addition of a series reactance as a change in the value of X_L. If we reduce X_L to obtain the required Q, the QX_L is reduced and R_G is not matched. Similarly, if X_L is increased, we again obtain a mismatch.

Fortunately, it is seldom necessary to couple into an antenna whose impedance is much below that usually found to be the proper terminating impedance of the network. At low radio frequencies, of course, this difficulty may very well be encountered. Although the normal antenna in this case may be so short electrically as to have low resistance, its capacitance in general will also be quite low. To resonate such an antenna, considerable inductance will be required in the loading coil. The resistance of such a coil will be comparable to the antenna itself, and added to it, will bring the resistance into which the network is coupled to a higher value. Of course, this added resistance represents a loss, but that loss was inherent in the circuit and not added by the coupling network. The whole matter may be resolved as follows:

At low frequencies (such as radio

*Everitt, W. L., Output Networks for Radio Frequency Power Amplifiers. *Proc. I.R.E.*, 19, No. 5, p. 725–737, May 1931.

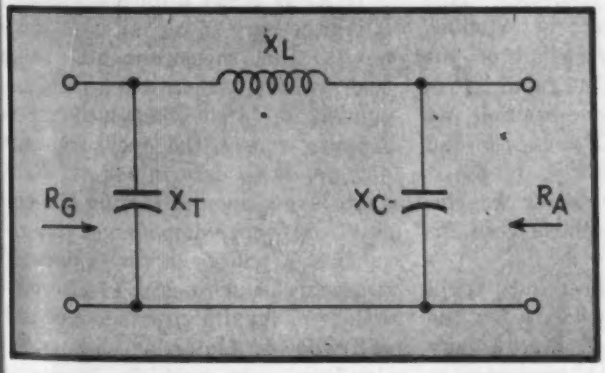


FIG. 2—Pi section used as a low-pass coupling network

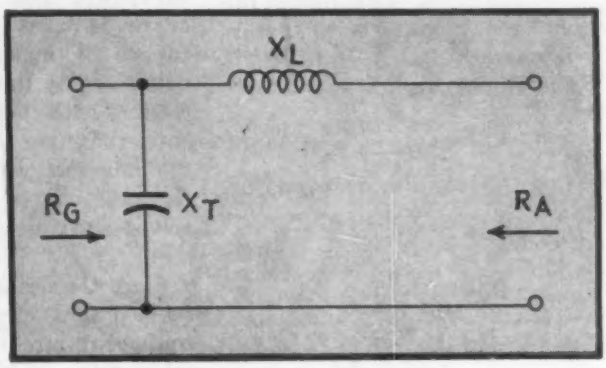


FIG. 3—Equivalent circuit of pi coupling network

beacon frequencies below the broadcast band), it is desirable to use a class C amplifier whose generator impedance is as low as possible, such as a low-voltage, high-current tube or tubes in parallel. This will make R_G and consequently R_A lower. If R_A is still greater than the effective antenna resistance, the resulting circuit would have a higher Q than required, and would, in effect, be undercoupled.

When the actual load, which we shall call R_L, is greater than R_A, the problem has a complete solution. A reactance in parallel with R_L will give a circuit whose impedance is lower than R_L. By properly choosing this reactance, the resistive component may be made equal to R_A, something which was impossible to do with additions of series reactances. This reactance should be capacitive, to increase harmonic suppression.

Development of π Circuit

It is interesting to note that we are throwing off the yoke of Eq. (4), since we are now resynthesizing the original π network of Fig. 2. However, for simplicity, and to maintain the analogy to coupled tank circuits, we shall continue to use the L network of Fig. 3. We shall treat this newly formed parallel circuit as an entity in terms of its series equivalent.

Figure 4(a) shows this parallel circuit, where R_L is a load greater than R_A, and X_C is the compensating capacitive reactance necessary to make the total circuit resistance look like R_A. Figure 4(b) is the series equivalent, where X_E becomes the effective series reactance of Fig. 4(a). It will be as though X_L had been reduced. To compensate, either X_L or the tuning capacitance must be increased. To maintain the original conditions, we will naturally increase X_L.

From Fig. 4(b),

$$R_A - jX_E = \frac{-jR_L X_C}{R_L - jX_C} \qquad (8)$$

Clearing j from the denominator,

$$R_A - jX_E = \frac{R_L X_C^2 - jR_L^2 X_C}{R_L^2 + X_C^2}$$

$$R_A = \frac{R_L X_C^2}{R_L^2 + X_C^2} \qquad (9)$$

$$X_E = -\frac{R_L^2 X_C}{R_L^2 + X_C^2} \qquad (10)$$

Solving Eq. (9) for X_C now gives

$$X_C = -R_L\sqrt{\frac{R_A}{R_L - R_A}} \qquad (11)$$

Equation (11) gives the value of compensating capacitive reactance X_C which will transform R_L into R_A. Figure 5 is a family of curves for this relationship, where R_L is plotted versus X_C for selected values of R_A.

In using Fig. 5, the range may be extended by multiplying all of the quantities by the same factor. For example, assume that it is required to find the reactance which

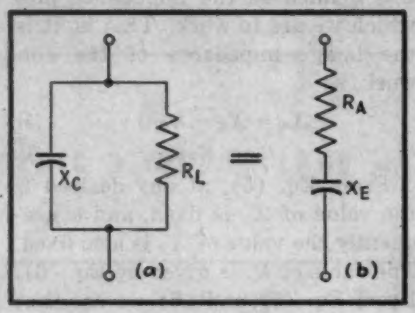


FIG. 4—Load with reactance in parallel (a), and its equivalent series circuit (b)

will transform an actual resistive load R_L of 60 ohms into one of 20 ohms. Since there is no curve in the range of $R_A = 20$, we will use the $R_A = 2$ curve and assume that R_L and X_C are also ten times their given values. We enter the graph from the left at the point $R_L = 6$. Traveling to the right we find that the intersection with $R_A = 2$ occurs at $X_C = 4.2$. Multiplying by ten, our answer is 42 ohms.

Equation (10) gives the series equivalent reactance introduced by X_C, this being the value by which X_L will have to be increased to compensate. Figure 6 is a family of curves for this relationship. This curve is also used in extended ranges by multiplying all of the quantities by the same factor. Proceeding with the above example, we enter the curve at $X_C = 42$, and find the intersection with $R_L = 60$ at $X_E = 28$ ohms. No factor was involved and the answer is read directly.

Since the design procedure for a coupled tank circuit holds for the equivalent circuit of Fig. 3, any calculations which the engineer is accustomed to make to determine the proper reactances to use for a coupled tank circuit hold equally well for the π network. Of course, in most cases only X_C would remain the same, while X_L would have to be increased by an amount equal to the value of X_E. Knowing X_C and Q, R_A could be readily obtained.

Terminating Impedance

At best, the calculation of the generator impedance of a class C power amplifier is only an approximation. An actual measurement under operating conditions is much to be preferred. While we cannot do precisely that, we are able to do what is even more to the point. The circuit lends itself admirably to a measurement of R_G, the resistance with which we actually wish to terminate the vacuum tube.

The circuit of Fig. 3 is set up with sufficient metering to obtain plate current, plate voltage and load current. In place of R_A we may use any convenient value which we shall call R_X. The circuit is then tuned by means of X_T and the output and input powers calculated. If we have not exceeded or equaled the rated power dissipation capabilities of the tube, X_L is reduced and the circuit retuned. This procedure is continued until, at resonance, either maximum or required power output is obtained within the limitations of tube power dissipation. In the case of pentodes, the screen as well as plate dissipation must be watched, particularly if the ratio of X_L to R_X is large. Having adjusted the circuit we have terminated it with the proper R_G. Since we know R_X or can measure it, by measuring X_L or X_T we are able to calculate R_G. From this data R_A is fixed according to the circuit Q which is to be used.

If R_X is much different from R_A it is necessary to repeat the adjustments and measurements using some value of R_X nearer to the calculated R_A. Just when it is necessary to repeat the measurements may easily be determined. If R_X is quite large, upon adjusting the circuit for proper impedance the resulting Q will be a low value. If it becomes much below 10, the conditions of maximum impedance and unity power factor will not occur simultaneously, and the harmonic generation will be appreciable.

Consequently, erroneous measurements will result. If, on the other hand, R_x is too low, X_L will be large in order to bring R_o to its proper value. This will result in a condition of undercoupling. The tube will be delivering full output possible under the conditions, but that output will be low as will be the input power. Since the internal impedance of a vacuum tube is a function of the operating conditions, R_o will be different from that under the required load conditions.

Antenna Measurement

In many cases, the actual antenna resistance R_L is not known. This too may be found experimentally. Since we already know R_o, by replacing R_x with the actual antenna, adjusting for the required power, and measuring X_L or X_T we have sufficient data to calculate the unknown load resistance. Here again we should have comparable values of load, and the first measurement will generally have to be repeated using a value of R_x more nearly the same as R_L. Of course, if equipment is available, the measurement may be made by the substitution method. This means, in most cases, having available power resistors, continuously variable, and with neglible or tunable reactance. The first method is quite accurate and more adaptable to the equipment of the normal laboratory or transmitting plant.

Note that for the antenna measurement, we are not concerned with R_o as it will finally exist, but simply wish to keep it constant for the two measurements, the one with R_x and the other with R_L. To be most accurate, therefore, all meter readings should be the same for both measurements. Low power may, of course, be used in this antenna resistance measurement.

Design Summary

The following outline summarizes the procedure to be followed in the design of a π coupling network.

1. Set up the circuit of Fig. 3 with any value of R_A, such as R_X. Adjust X_L until when tuned by X_T the required power output within dissipation limits is obtained. Measure R_x and X_L or X_T. The required load impedance R_o is given by Eq. (7).

2. Select a value of Q for the required harmonic attenuation and calculate X_L and X_T from Eq. (5).

3. Find the value of R_A from Eq. (6).

4. Replace R_x by R_L, the actual load, and adjust the circuit for the required power output. Measure X_L or X_T, and using the value of R_o found in step 1, calculate R_L from Eq. (7) solved for R_A, which in this case is R_L.

5. Replace this value of R_L by an R_x of approximately the same value and repeat steps 1 and 4.

6. If neither the value of R_x used in step 1 nor the value in step 5 is approximately equal to R_A, repeat steps 1, 2 and 3 using an R_x more nearly the same as that of R_A as found in step 3.

7. Find X_C from Fig. 5 or from Eq. (11).

8. Find X_x from Fig. 6 or from Eq. (10).

9. Increase X_L by X_x.

If reasonable care has been exercised, the circuit will be found to tune within a small percentage of the calculated X_T, and the final adjustments will be easy to make.

If X_T was varied very much in achieving tuning, this will alter the Q and should be corrected. Let us examine the case where X_T was increased for tuning, knowing that if it were decreased the reverse procedure would hold. In order to decrease X_T (increase the capacitance), either X_x must be increased or X_L decreased. The effect on the power output will clearly indicate which is required. An examination of Fig. 6 will show whether X_C is to be increased or decreased to cause the proper change in X_x. It will be seen that up to the point where X_C is equal to R_L an increase in X_C will cause an increase in X_x. When the value of X_C is greater

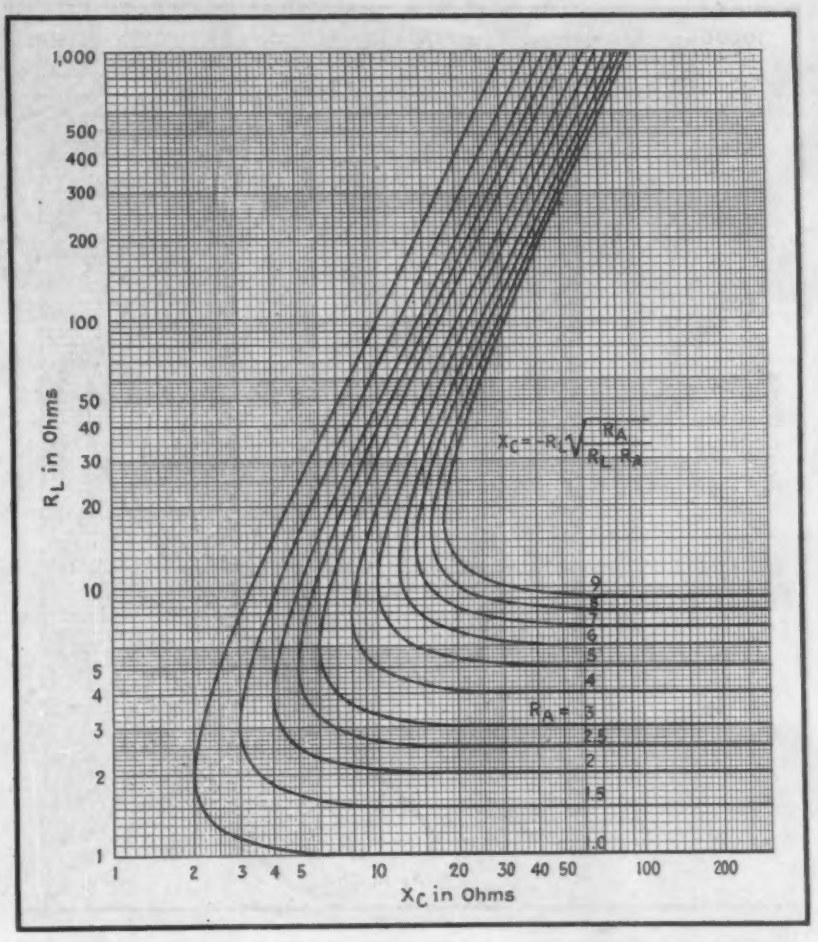


FIG. 5—Chart giving value of compensating capacitive reactance X_C required to make load circuit have correct resistance for matching purposes

than R_L a decrease in X_C is needed to cause an increase in X_E. Incidentally, it is just this effect that makes the adjustment of a π network by cut-and-try methods so confusing to the uninitiated. Not only can tuning be accomplished by any of the three reactances, but the change in the direction of the effect of changes in X_C produces apparently uncorrellated results.

Example

Probably the best method of explaining the design procedure is to work out a typical design. The following example is actual observed data.

1. The circuit of Fig. 3 is set up, choosing initially for R_A the value $R_A = 60$ ohms. X_L is adjusted for maximum power output, then measured and found to be 308 ohms. From this, $R_G = X_L^2/R_T = 94{,}900/60 = 1580$ ohms.

2. Using a Q of 12, $X_L = X_T = R_G/Q = 1580/12 = 132$ ohms.

3. $R_A = X_L/Q = 132/12 = 11$ ohms.

4. Inserting the actual antenna and readjusting for maximum power output, X_L is found to be 413 ohms. From this, $R_L = X_L^2/R_G = 171{,}000/1580 = 108$ ohms.

5. Steps 1 and 4 are repeated using $R_T = 108$ ohms. Upon readjustment, X_L is found to be 425 ohms, and $R_G = X_L^2/R_T = 181{,}000/108 = 1660$ ohms. Replacing R_T by R_L and again readjusting, X_L is measured as 417 ohms, and $R_L = X_L^2/R_G = 174{,}000/1660 = 105$ ohms.

6. Since R_A and both values of R_T are quite different, we will repeat steps 1, 2 and 3 using $R_T = 15$. When adjusted now, $X_L = 149$ ohms, and $R_G = X_L^2/R_T = 22{,}200/15 = 1480$ ohms. At a Q of 12, $X_L = X_T = 1480/12 = 123$ ohms, and $R_A = X_L/Q = 123/12 = 10$ ohms.

7. Using Fig. 5, we enter at $R_L = 10.5$ ohms, and the intersection with $R_A = 1$ occurs at $X_C = 3.4$. Since a factor of 10 has been used, $X_C = 34$ ohms.

8. Using Fig. 6 we enter the curve at $X_C = 340$ and, assuming a curve $R_L = 105$ to exist slightly above $R_L = 100$, we can estimate the intersection to occur at $X_E = 30$. Since a factor of 0.1 was used, $X_E = 3$ ohms.

9. X_L is, therefore, increased to 126 ohms.

Our final circuit has $X_T = 123$ ohms, $X_L = 126$ ohms, and $X_C = 34$ ohms. It properly terminates our tube when loaded by a resonant antenna of 105 ohms, yielding a circuit Q of 12. In actual practice, this tuned almost perfectly as calculated, and the change in X_T to produce exact tuning was too slight to warrant any further changes.

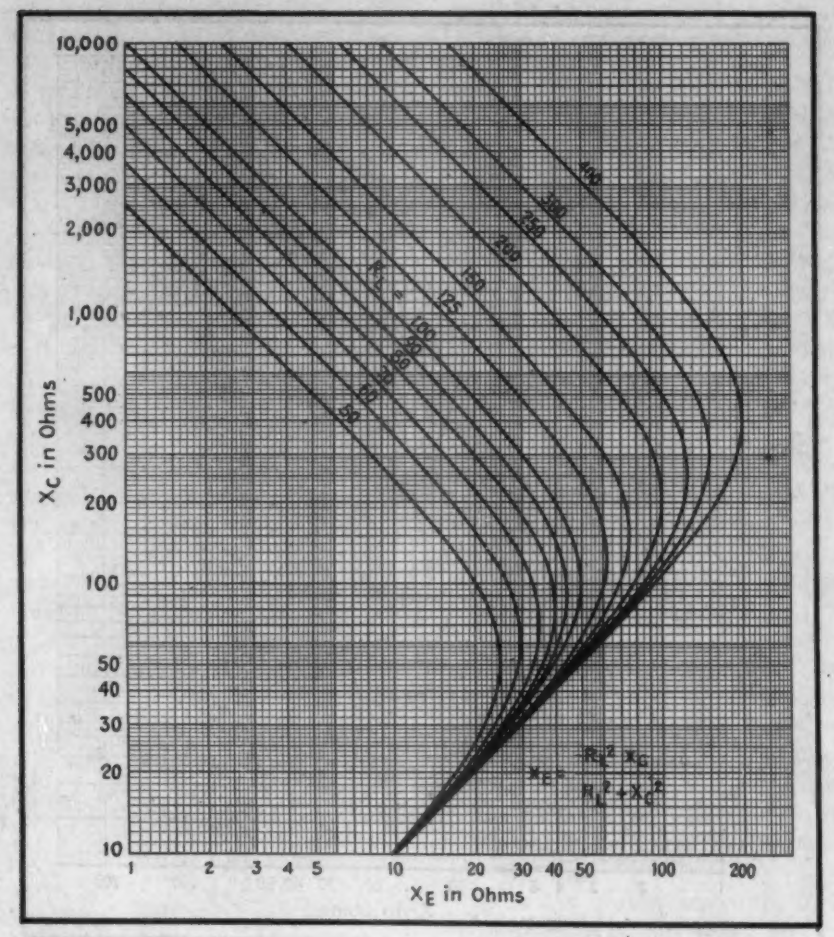


FIG. 6—Chart giving reactance value X_E by which the inductive reactance X_L in the network must be increased to give correct tuning

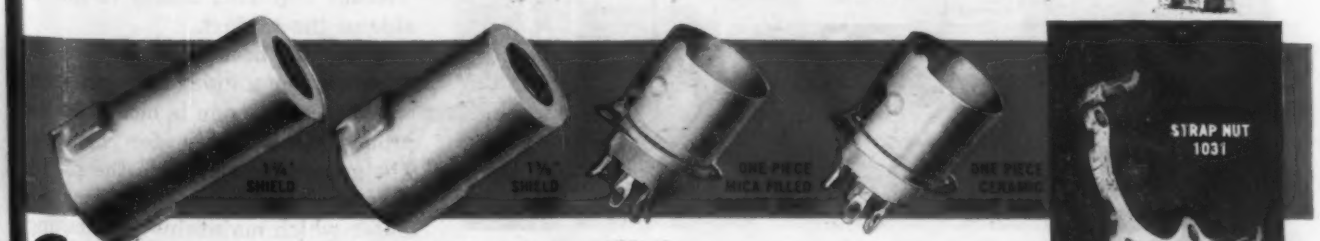
Conclusion

The foregoing assumes that means for making reactance and resistance measurements are at hand. In the field, particularly using emergency equipment, this will not be so. However, it is hoped that sufficient light has been thrown on the subject to enable "blind" tuning to be accomplished logically and rapidly.

As a suggestion, start with an L network, resonate the antenna, and then add output capacitance as required. Up to a point, increases in capacitance and inductance will bring up the antenna current. Thereafter, the current will start to drop off. In other words, at first R_L is too large to achieve a low enough R_G. As X_C reduces the effective R_L the current will increase to the point of overcoupling and excessive power output, as evidenced by excessive plate current. Further reduction of R_L or increase in X_L will be in the direction of low coupling and high Q, which is, of course, more desirable. For safety, then, adjustment is continued in this direction until the plate meter indicates that not too great a plate input is being delivered to the tube. With a little experience, one will easily learn the "feel" of π network adjustments, and will work out rapid and surprisingly accurate methods of tuning without any equipment other than the transmitter meters.

On the Alert

Now may be an appropriate time to direct attention to leadership that has proven itself under the most severe war demands and conditions: Cinch, alert and anticipating electronic socket requirements, presented to the industry a complete line of miniature socket assemblies—long before general wide spread manufacture. ★



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SUBSIDIARY OF UNITED-CARR FASTENER CORPORATION, CAMBRIDGE, MASS.

INDUSTRIAL CONTROL

Electronic Heating of Plastic Preforms 146

Electronic Vulcanizing of Tires for Army Trucks 148

X-Ray Ceramic Products 152

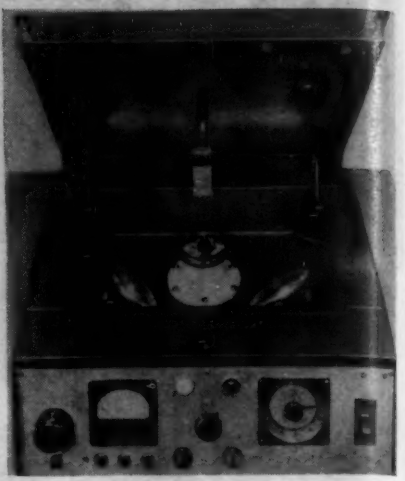
Production Tester for Mica Capacitors 156

Electronic Heating of Plastic Performs

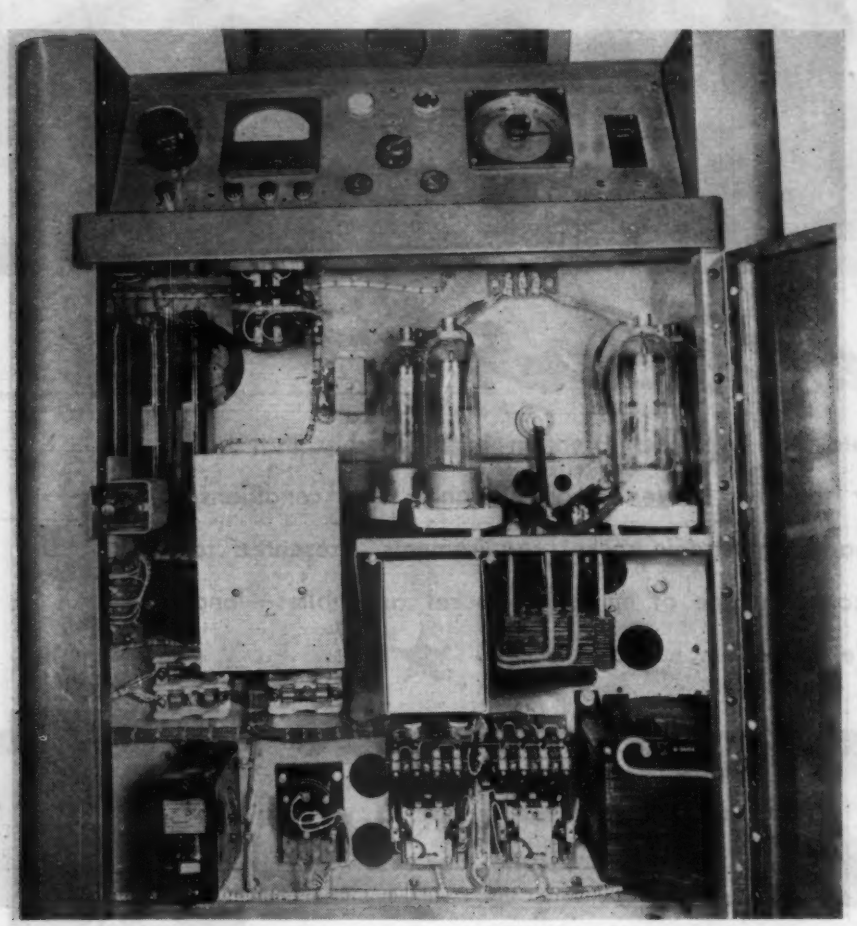
IN THE MANUFACTURE of plastic products, uniform and rapid preheating provided by dielectric heating softens the entire preform to an easily moldable state and eliminates gases before molding. This action greatly reduces the chance of warping or blistering the work piece in the mold and virtually eliminates the risk of damage to the mold. Since the molding cycle is cut from hours to minutes in some applications, production time is also saved.

Especially designed for heating plastic preforms, a new RCA r-f generator is a package unit that delivers up to 2000 watts of power, or 6800 BTU per hour, into a dielectric load of average characteristics. An operating frequency of approximately 27.4 Mc permits rapid heating of a wide variety of materials without danger of arc-over between plates.

To pre-heat plastic preforms for molding, the operator places the preform on the bottom electrode, then closes the counter-balanced lid, automatically bringing the retracting upper electrode into contact with the work, and presses the starter button. The top electrode mounting and operating mechanism is designed to permit the electrode to seat flat and exert uniform pressure on any thickness of preform within its operating range. At the end of the heating cycle, a pre-set timer automatically opens the lid and shuts off the power.



Close-up of the control panel and heating chamber of the RCA r-f generator. The open-mesh cover permits gases to escape during heating of the preform while two infrared lamps provide radiant heat to prevent cooling of the preform surface by surrounding air



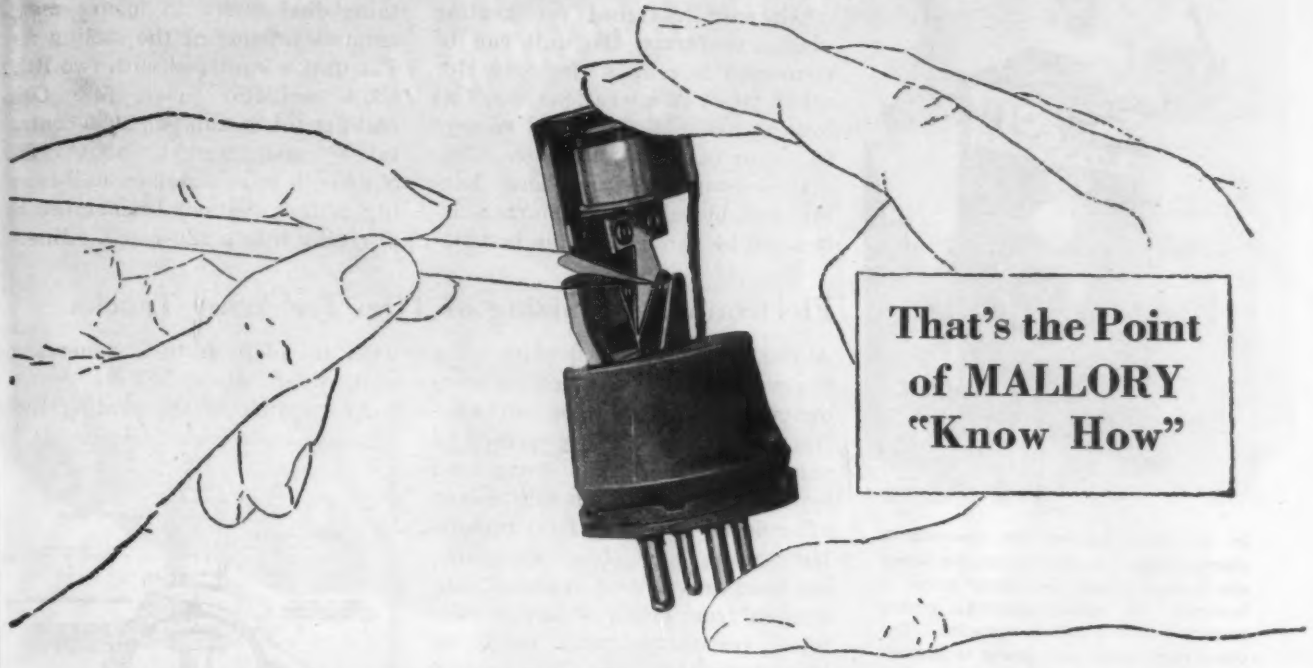
The electronic power unit of the RCA model 2-B dielectric heating unit for heating plastic preforms

Controls

Timer, power controls, and indicators are mounted on a control panel, placed just below the lid and tilted for visibility and convenience. Access to tubes and components of the generator equipment for servicing and replacements is provided by front and rear doors in the body of the cabinet, both equipped with power disconnect switches and key locks to prevent entry except by authorized maintenance personnel. Changes in operating setup are quickly made by means of the front panel controls, without requiring access to the inside of the cabinet.

Once the best treatment is determined for a given type preform, each successive one is heated to the proper temperature for molding. The generator, shown in the photographs, contains an electronic regulator which maintains the heating rate constant at a predetermined value, irrespective of normal varia-

CONTACTS
Can Make or Break a Vibrator



Contacts in a vibrator take a lot of punishment. They must operate under widely varying conditions of temperature and must "make and break" 115 times a second. Small wonder that alert engineers think of contacts first when selecting a vibrator!

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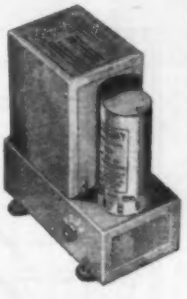

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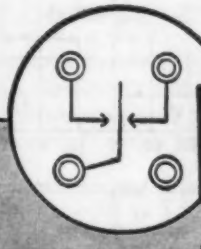

P. R. MALLORY & CO. Inc.

MALLORY VIBRATORS

AND VIBRATOR POWER SUPPLIES

In the photo above, the operator is shown placing a preform on the lower electrode. When the mesh cover is lowered, the upper electrode makes contact with the plastic material. The cover pops open and power is shut off at the end of a predetermined heating interval

tions in preform shapes or chemical and physical changes which occur during the heating cycle.

A synchronous motor timer, adjusted by means of a knob on the front panel, may be set for time cycles from two seconds to 120 seconds, depending on the size of the work piece and other factors involved in a specific application. The unit will heat up to one pound of molding material per minute. An additional feature consists of two infrared lamps, installed in the heating chamber, to provide auxiliary radiant heat to prevent cooling of the preform surfaces by the surrounding air.

Equipment Safety

In addition to safety features designed to protect operators, the equipment itself is thoroughly protected. An r-f filter is included to guard against r-f radiation via the power circuits. The unit is completely shielded to minimize the possibility of direct radiation.

Automatic overload relays guard against tube overloads, and an automatic time-delay relay prevents damage which might otherwise result from starting the unit without an adequate filament warm-up. An automatic voltage regulator, capable of handling a line voltage range of 190 to 260 volts, supplies constant filament voltage.

Although designed for heating plastic preforms, the unit can be connected to remote electrodes for other types of operations, such as heating assemblies of wood veneers to set or cure the glue lines.

Close-coupled external loads having suitable electrical characteristics can be handled by the installation of an appropriate fitting for passage of a short transmission line.

Equipment beneath the heating chamber is cooled by air from a built-in blower system that contains dual filters to insure maximum cleanliness of the cooling air. The unit is equipped with two RCA 833A oscillator tubes, four 8008 rectifier tubes, and two 2050 control tubes, and weighs about 800 pounds. It is mounted on ball-bearing casters and may be installed by plugging into a 220-volt a-c line.

Electronic Vulcanizing of Tires for Army Trucks

A TIRE LIFE of 100,000 miles after the war may be provided by commercial development of an electronic dielectric heating method of vulcanizing rubber now being used by the Army as a mobile means of quickly effecting tire repairs. Heretofore, heat for vulcanizing has been provided by means of conduction from either steam or electrical resistance metal molds or open steam chambers. This type of equipment as used by the Army permitted a total of about ten repairs per hour. An example of the weight involved is suggested by the weight of an open steam repair unit which, with its tanks, weighs about twelve thousand pounds. It is flexible as to tire sizes but not portable on a standard size Army truck permitted near the front lines. In comparison, the electronic unit, in addition to a generating unit, weighs about 500 lb.

An example of the heating time

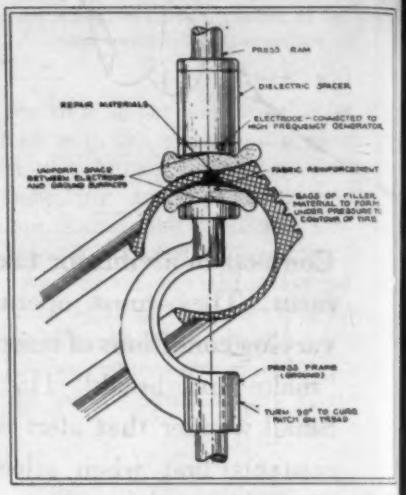
PRESS RAM
DIELECTRIC SPACER
REPAIR MATERIALS
ELECTRODE - CONNECTED TO HIGH FREQUENCY GENERATOR
UNIFORM SPACE BETWEEN ELECTRODE AND GROUND SURFACE
FABRIC REINFORCEMENT
BAGS OF FILLER MATERIAL TO FORM UNDER PRESSURE TO CONTOUR OF TIRE
PRESS FRAME (GROUNDED)
TURN 90° TO CURE PATCH ON TREAD

Fig. 2—Bags of filler material act as flexible molds for curing tire patches with dielectric heating

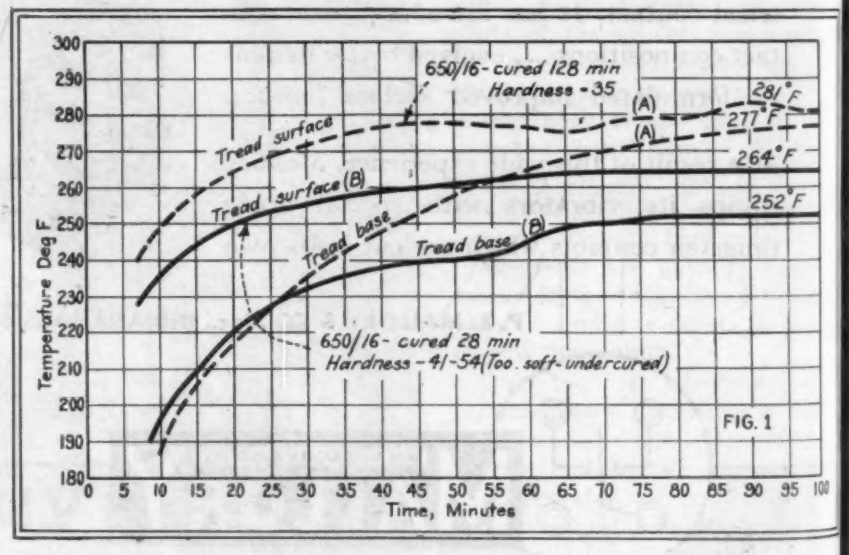

Fig. 1—Curing curves of steam pressure method of vulcanizing as shown by thermocouples placed at the tread surface and tread base. The curves marked *A* were obtained from one mold. A different mold was employed when curve *B* was plotted

for example:

ELECTRONIC TIMING

Industry is making increasing use of electronic timers in timing or controlling intervals that are beyond the accuracy and scope of mechanical measurement. Such applications as measurement of the speed of a camera's shutter, welding control, plastic molding, photographic exposure and measurement of turbine speeds are typical.

Series 175 Relay

THERE'S A JOB FOR *Relays* BY GUARDIAN

The above diagram of an electronic timing circuit shows a capacitor and an adjustable resistor connected to the grid of a thyratron or "trigger" type of tube. As the capacitor discharges, the grid potential reaches a point where the tube becomes conductive and energizes a relay.

The relay is generally a fast-acting type such as the Guardian Series 175 operating at a speed which minimizes interference with the timing interval. Coil operating voltages range from 6 to 110 volts D.C. (Also available for A.C. in Series 170). Contacts are rated at 12½ amps. at 110 volts, 60 cycles, non-inductive in combinations up to D.P., D.T. Bakelite base is molded to reduce surface leakage. Has binding post terminals in place of solder lugs. Write for Bulletin 175.

Consult Guardian whenever a tube is used—however—Relays by Guardian are NOT limited to tube applications but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

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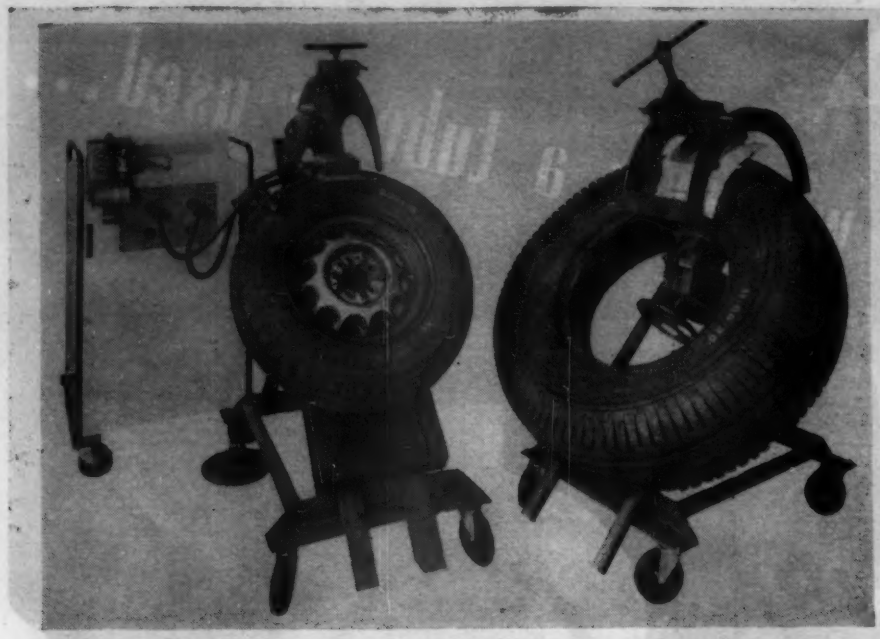

The r-f generator and two fixtures of the Vulcatrone development for repairing tires by means of dielectric heating. The fixture at the right is designed to vulcanize small sectional and spot repairs, the one at the left handles spot repairs only but also cures sidewall, corner or tread patches to cord depth without removing the tire from the rim

of the older method of vulcanizing is given in Fig. 1 where the curves represent temperatures at tread surface and tread base of tires during cures in molds. A variation of from 12 to 50 deg on the outside tire surfaces between the top and bottom of tread is also shown.

Development work on the dielectric heating project was instigated by Lt. Col. C. W. Vogt, Chief of the Technical Staff for Supply, Transportation Corps of the Army. He worked in conjunction with the Lakso Company of Fitchburgh, Mass. Test apparatus was made up and tried out at Forest Products Laboratory, Madison, Wis. where several sizes of high frequency generators were available. The tests showed that a type bag, filled with pulverulent material arranged as in Fig. 2, would:

1—Adjust itself readily to variations in shape and thickness of tires at shoulder, sidewalls, and treads.

2—Make possible spot and sectional cures in a few minutes and with a minimum of temperature differences throughout these varying thicknesses of sections.

3—Maintain satisfactory sharp shoulder edges to correspond with edges of the tires adjacent to the area of cures.

Since the tests at Madison, numerous experimental tire repairs have been made and some of these tires have been tested to destruction and found entirely satisfactory. Tests using thermocouples at various points show that even at ten times the speed of temperature rise in the center of area cure, temperature variations are considerably less than that obtained on present day conventional repair apparatus. Figure 3 shows that practically uniform temperature is maintained throughout the tire thickness.

Flexible Mold

The sectional repair unit is based on the principle of having the material to be heated placed between two spaced electrodes. The variation in thickness between the tread corner and sidewall is compensated for by a bag containing a flowable noncompressible material, this bag automatically forming a mold of the proper shape and enabling uniform pressure to be applied to the patch area.

The fixtures to hold the tires are designed so that a minimum of labor is involved in the setting up operation. The tire is laid into the fixture and from then on is positioned by handwheels. The high frequency generator shown in the photograph is the laboratory model, the field units being of more rugged construction and having a minimum of dials and controls.

At a meeting of the Society of Automotive Engineers at Philadelphia in June, Colonel Vogt delivered a paper on the electronic vulcanizing process and included excerpts from an official report of Aberdeen Proving Ground. The report stated that repaired tires were subjected to road tests which the Automotive Section has regarded as highly satisfactorily. The report went on to say that,

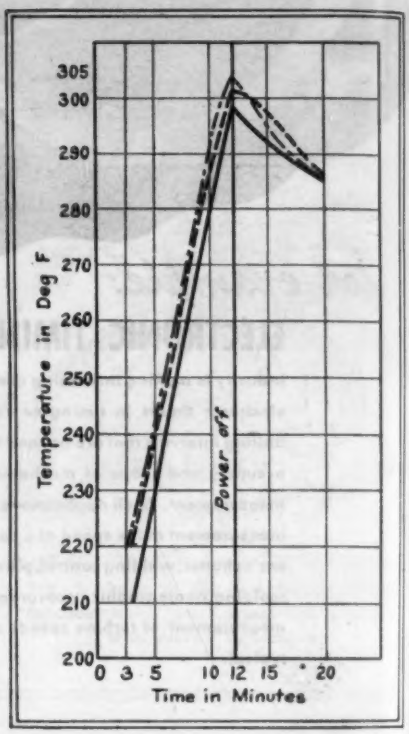

Fig. 3—Curing curves of dielectric heating for tire repair as shown by thermocouples placed at several points. The solid curve represents temperature at surface of lining; dotted curve, at center of tire; dash-dash curve, at tread surface. All were recorded at point of axis of the press

with present standard equipment, the average time for individual cure of a spot or section may run over two hours. With the experimental electronic equipment, curing is accomplished in ten minutes.

Radiation

Colonel Vogt said that because of the possibility of radio interference with other electrical systems, such as radar and communications

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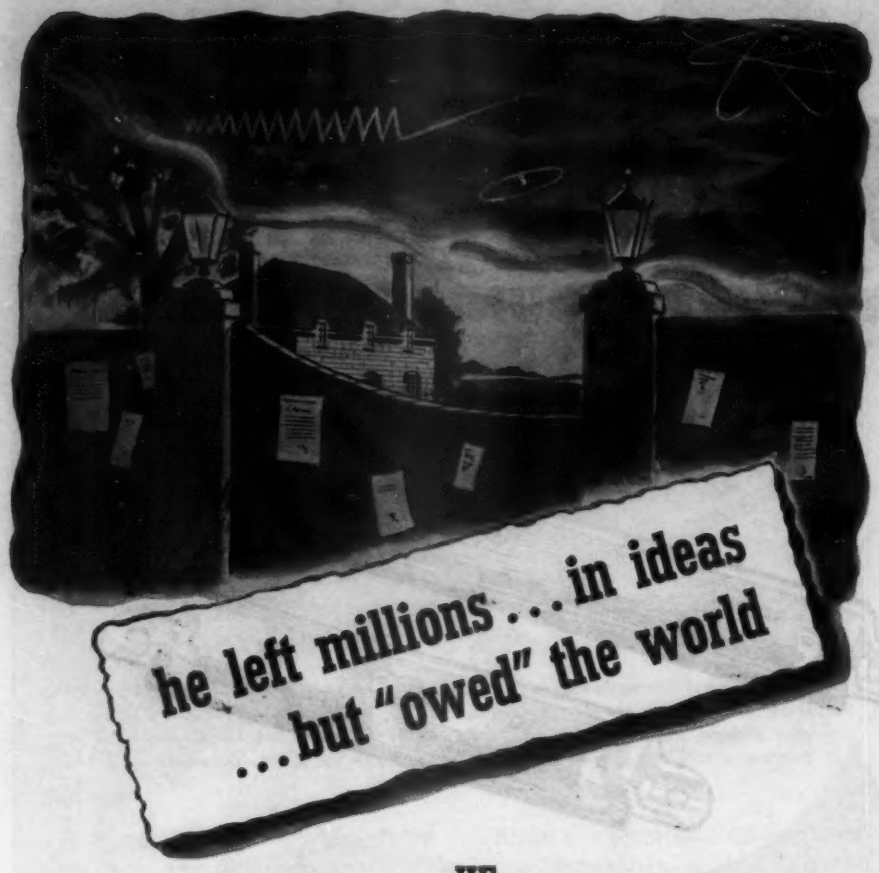

HE called himself a "philanthropist", and yet the door of his villa at Torquay in France was nailed with notices for unpaid debts. He gave away discoveries worth millions of dollars to the communications industries. He founded the modern science of telephonic communication. His name? Oliver Heaviside.

Advance theories of communication have been forced into practice by urgent war needs. Fundamental to all new developments, in this and other fields of electricity, is the transformer. Stancor engineers are fully conscious of their responsibility to keep pace with and to set pace in their transformer designs for tomorrow's peacetime industry.

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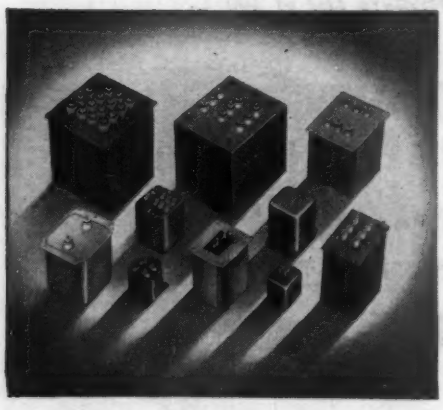

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equipment, the Signal Corps sent one of their mobile testing sets to determine the extent of this interference so that the necessary provisions could be made to prevent harmful interference. A simple screening with the usual interlocks can be applied without slowing down or adversely affecting the speed, flexibility or operation of the electronic heating tire repair unit.

"Another little known fact," said Colonel Vogt, "which has been learned during our development work is that livelier cures are made by the few minutes application of 'internal' heat as contrasted to an hour or more of impressed or external heat. Contact with the heated molds for an hour or more, causes a heat embrittlement of this outer tire surface resulting in appreciably reduced mileage from this embrittled and case-hardened rubber.

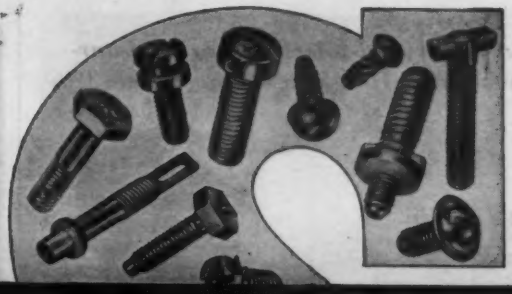
"In order to produce the proper heat in the center of the rubber tire mass, an excessive heat has been necessary, time and temperature-wise, on the outside of this mass. This applies not only to repairs and recapping but also to new tire manufacture. Probably the reason that this condition is not more widely known is that apparently no means has been available heretofore to overcome excessive surface heat in order to produce proper internal temperature at the core of the rubber.

"While our tests indicate that both recapping and new tire production may advantageously utilize methods we have evolved during these last months, we have studiously avoided branching out commercially into these phases, keeping in mind our primary purpose of making available as quickly as possible to the armed forces, a light weight, highly mobile unit, for effecting tire repairs on a wide range of tire sizes."

• • •

X-Ray Ceramic Products

THE RESULTS of an investigation of problems in the manufacture of ceramic materials, insulators, glass, refractories, crucible and chinaware were announced by John P. Nielson, application engineer of North American Philips Co., at the annual convention of the American



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AS CRYSTAL specifications become more and more rigid, more and more communication equipment builders are meeting the "specs" by acting on the suggestion, "Let's call in Crystalab."

There are good reasons for this fact:

1 From the beginning, Crystalab has been meeting the rigid specifications set by the U. S. Coast Guard, the U. S. Signal Corps, and other branches of the armed services . . . the standards which are the basis of specifications now used by most of the industry.

2 Crystalab testing equipment, much of it designed and built by our own engineers, is unsurpassed in the industry. It includes instruments for testing the performance of crystals under all temperature and frequency conditions. Thus, when a crystal leaves Crystalab, it is accurate to highest precision standards.

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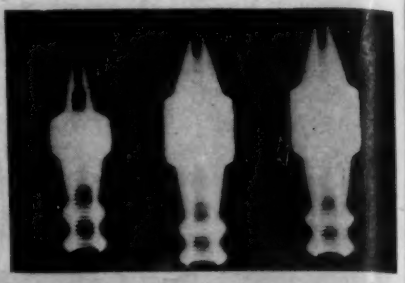

X-ray photograph of spark-plug porcelains that failed under test. The original picture shows small cracks in two units and a metal particle embedded in the third

Ceramic Society in Pittsburgh. Some twenty ceramic companies cooperated in the investigation.

Radiographs, taken with Norelco Searchray equipment, of a number of different products were shown. These included spark-plugs (shown in the illustration), firebrick, refractory furnace orifice rings, and plate and lead glass. In all cases, the x-ray photographs showed hidden defects such as internal cracks, voids and foreign matter, that were not visible externally.

Bread plates that were x-rayed before and after glazing showed the uneven distribution of the glaze after firing. The glaze material contains substances of high atomic weight that cause a high ray absorption and, although thin layers of the material are usually applied, uneven layers show up the radiographs. Pieces of plate glass and lead glass that appeared identical to the eye were shown to be quite

Rayproof and shockproof. A girl operator adjusts the controls of the Norelco Searchray model 150. Made by North American Philips Co., the unit has a built-in indirect fluoroscope and a potential limit of 150 kvp

Above: Master Government Clock located at U. S. Bureau of Standards, Washington, D. C.

Master testing instruments are required to be unfailingly accurate at all times. Comparable, for example, to the U. S. Master Clock which regulates all government time is the RAULAND Frequency Standard which makes possible the *almost unbelievable* control accuracy of *1/100th of 1%!* Its maximum backlash is *.007 of one degree* or *one part in fifty thousand* . . . and this precision control is maintained throughout the entire range of minus 30° C. to plus 50° C! A typical example of RAULAND engineering thoroughness and craftsmanship.

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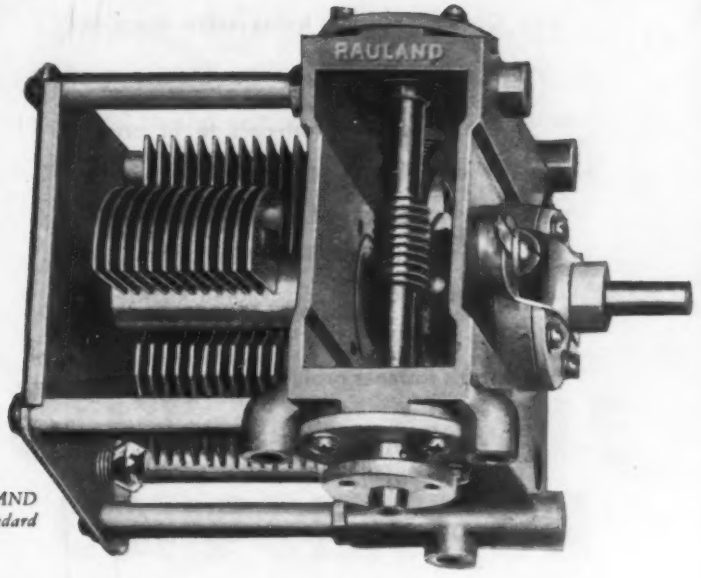

Right: RAULAND Frequency Standard

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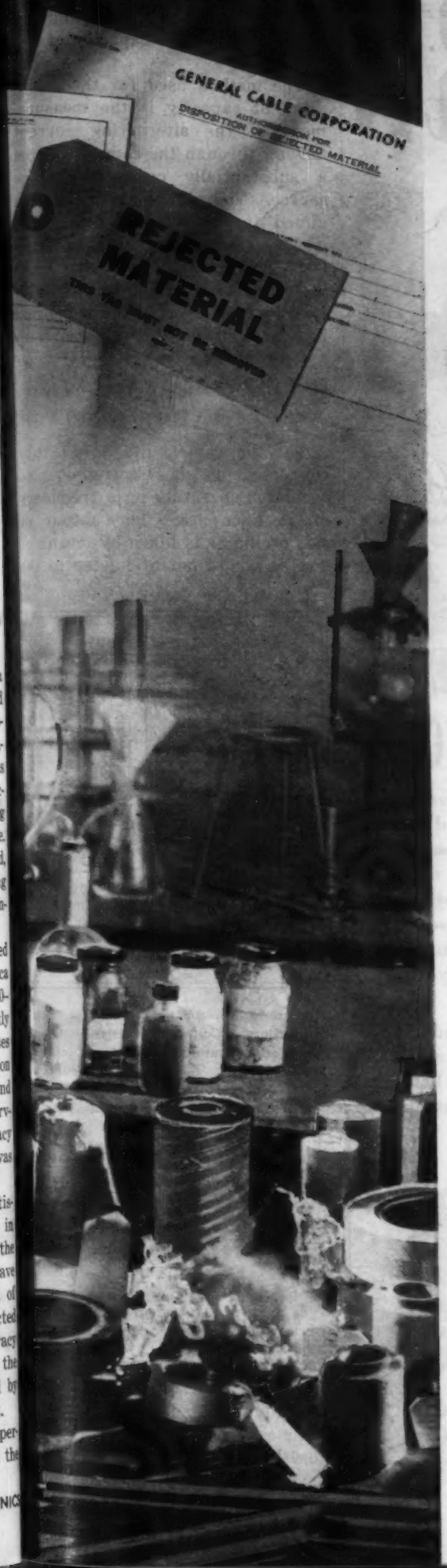

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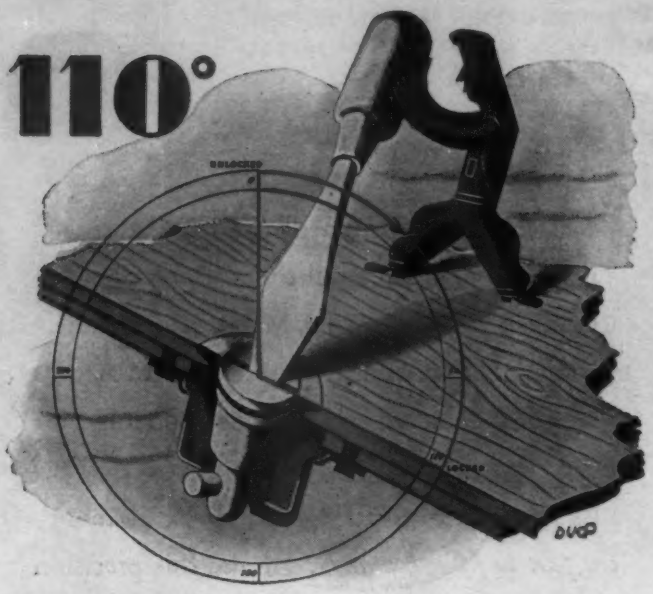

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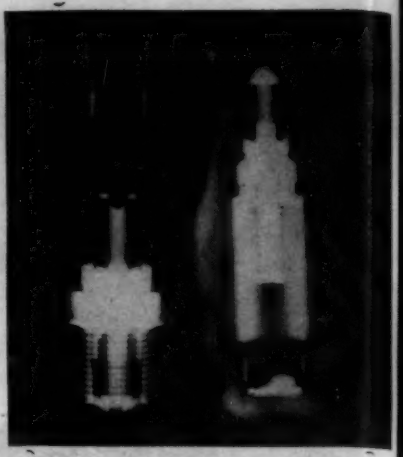

Two assembled spark-plugs for aircraft are shown in this radiograph. 200 plugs may be x-rayed at a time on one film

different when radiographed. The greater absorption of the ray by the lead makes it possible to determine small differences in lead content of lead glass.

• • •

Production Tester for Mica Capacitors

IN THE MANUFACTURE of mica capacitors, a method of rapid measurement of capacity is necessary for sorting and other operations. Bridge balancing methods are useful and capable of high accuracy and are used where grading to narrow tolerances must be done. Where less accuracy is required, more rapid direct capacity reading arrangements recommend themselves.

The equipment to be described was developed for sorting mica capacitors within the range 100-1200 $\mu\mu$f and is calibrated directly for this range. The unit possesses the qualities needed for production test equipment as it is small and compact, simple to use and to service, and supplies sufficient accuracy for the purpose for which it was intended.

For mica capacitors, it is satisfactory to measure capacity in terms of impedance, neglecting the effect which capacitor losses have on this impedance. Capacitors of bad power factor will be rejected by other tests and, for the accuracy of capacity required in sorting, the impedance modification effected by the loss factor is not significant.

Capacity accuracy to a few per cent is usually satisfactory and the

gether than on the 0-500 $\mu\mu$f part of the scale.

A switch with spring return is incorporated to switch the test terminals to an internal standard 500-$\mu\mu$f capacitor to which reference can be made whenever desired. The oscillator, due to the grid leak bias arrangement, tends to maintain a constant amplitude of oscillation but any variations due to valve ageing, etc., are compensated for when required by a screwdriver adjustment of the output potentiometer.

The same principle can be used for other ranges of capacity. For reasonable linearity of the scale, the capacitor impedance should be several times that of the other impedances in series with it, i.e., the 1000-ohm resistance and rectifier and the section of the output potentiometer across which the voltage being used is developed.

Other uses for the tester than the one for which it was developed suggest themselves. Among these are thickness, moisture and other evaluations which can be made by measurement of capacity or dielectric constant.

• • •

FREE FRENCH OP

Operating at an airfield on Gibraltar, Madeline Portalis, member of the French Service Feminines de la Flotte, gives landing instructions by radio from the control tower to an incoming pilot

(Photo Courtesy of U. S. Coast Guard.)

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Serve around the World

In this war, the seven seas have seen the churning wake of swift Coast Guard Ships; and on the seabags of members of the Coast Guard we find such names as Aitu Toya, Fedala, Tulagi, Florida Island, Guadalcanal, Sydney, Attu, Amchitka, Gela, Licata, Singapore, Murmansk, Salerno, the Marshalls, Makin . . . Like the U. S. Coast Guard, Jefferson Electric Transformers are serving *around the world,* too.

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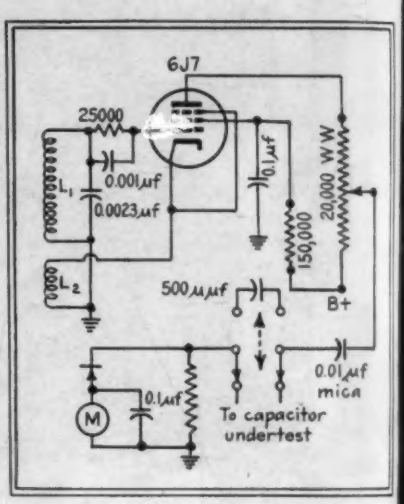
effect on impedance of a power factor even of 0.5 percent would not affect the nominal capacity of the capacitor.

The method used for the evaluation of capacity is the measurement of the alternating current flowing through the capacitor from a substantially constant voltage source. The utmost simplicity was aimed at and for this reason the use of stabilized alternating current generators or negative feedback amplifiers was dispensed with and, instead, a rapid check method was incorporated in the tester with a screwdriver adjustment for compensation.

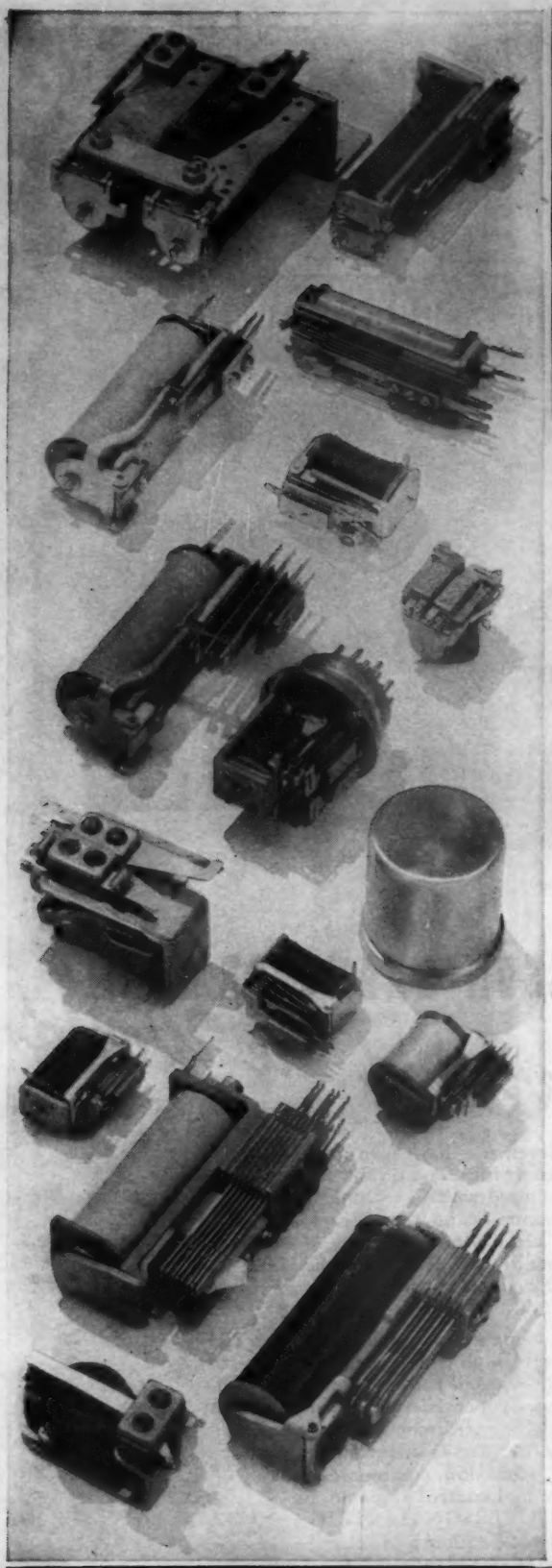
Circuit

The diagram shows a 6J7 tube connected as an electron-coupled oscillator operating on a frequency of 25 kilocycles. The output of this oscillator is taken by means of a wire-wound potentiometer to the



Circuit for rapid measurement of mica capacitors. Coil L_1 consists of three pies, each containing 500 turns of No. 40 SWG on a ½-inch form. Feedback coil L_2 contains 200 turns of No. 36 SWG wound between the pies of L_1

terminals of the capacitor under test. In series with this capacitor a 1000-ohm resistor is connected to ground. Across the 1000-ohm resistor, a half-wave copper-oxide rectifier and a 0-1 d-c milliammeter are used to give a measurement of the current flowing through the resistance by measuring the voltage across it. The milliammeter scale is calibrated in 100-$\mu\mu$f steps from 100–1200 $\mu\mu$f. Towards the end of the scale there is a tendency for the 100-$\mu\mu$f steps to be closer to-



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Television Standards

(*Continued from page* 97)

the NTSC to permit the use of mechanical scanning devices in the receiver, should such prove advantageous. The RTPB Panel made no changes in these standards.

The remaining standards (18, 19 and 21) relating to the method of rating television transmitters the maximum white level, and the polarization of the emitted waves, are identical to the previous recommendations of the NTSC.

In summary, the RTPB Panel has modified the NTSC-FCC standard in one respect (reducing the maximum deviation of the frequency modulated sound signal and increasing the sound signal radiated power) to permit easier use on the higher frequency channels, and has tightened the standards in two respects (by the elimination of an alternative method of picture modulation and an alternative vertical sync signal which is believed to have no particular merit). Otherwise, the standards remain as set up and adopted in 1941. This is in itself a tribute to the work of the NTSC and of its predecessor, the RMA Committee on Television.

Standards of Good Engineering Practice

In addition to the primary standards of television transmission just described, proposed "standards of good engineering practice" were studied by Committee 5 of the Panel. These include tolerances (such as those expressed in standards 15, 16, and 17 of Table II), certain transmitter operating characteristics, and methods of measurement which relate to the basic standards.

Strict specification was deemed impractical in many cases. For example, the linearity of sweep circuits in the camera was discussed and a method of measuring it described, but no strict tolerances laid down. The "dynamic characteristic" of the transmitter (the relationship between subject brightness in the studio and transmitter output voltage), is recommended to be "substantially logarithmic". However, no tolerances are set up, pending further studies.

Methods of measuring the side

microphones the networks use"

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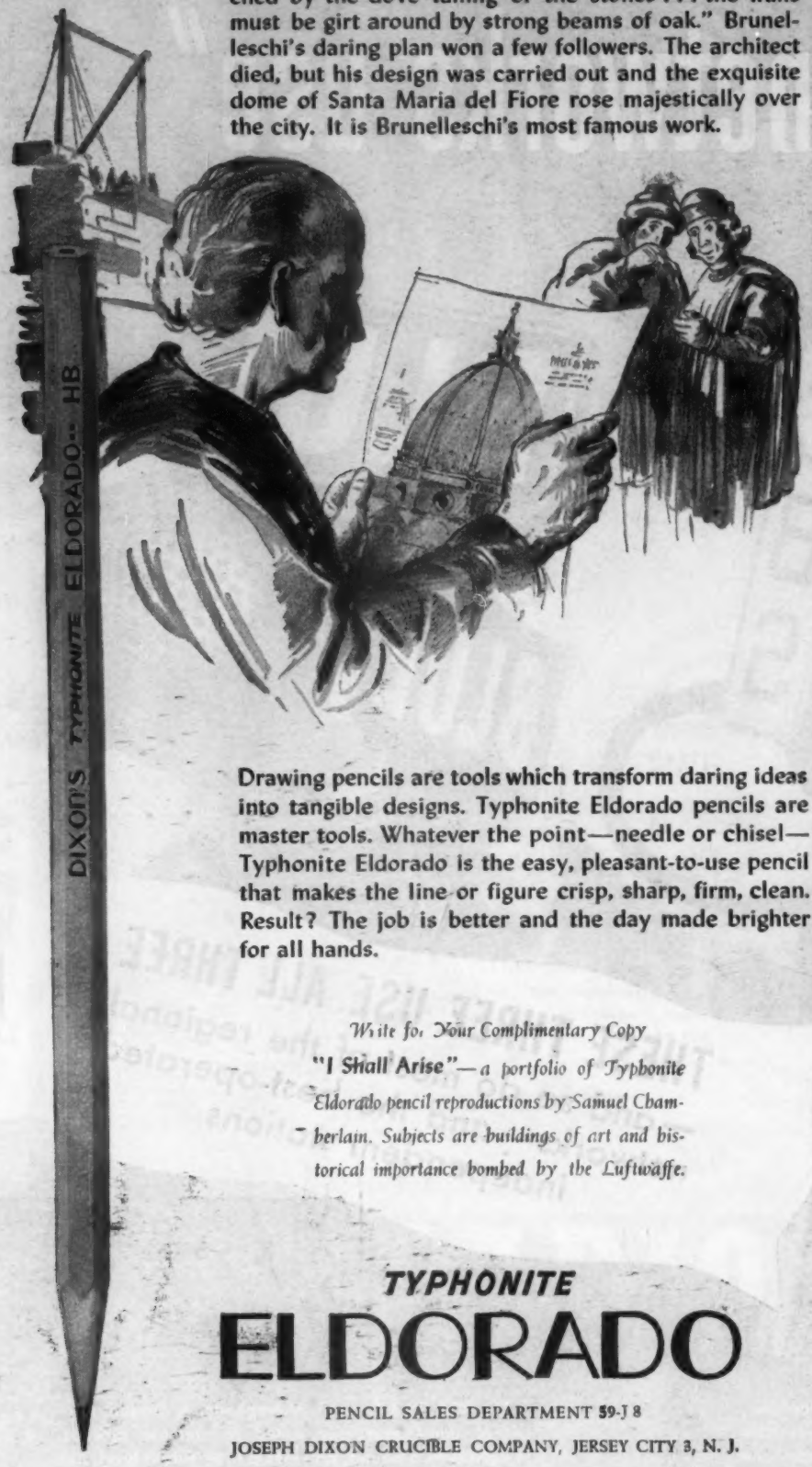

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bands in the transmitter output, to conform with the standard shown in Fig. 4, are also proposed. The modulating signal consist of sync pulses and variable-frequency sinewaves whose peak-to-peak amplitude is 0.5 the peak sync-pulse amplitude. The sinewave frequency is varied throughout the video range and the field strength radiated by the transmitter measured, against the 100-kc sideband as a reference. In case field strength measurements are not sufficiently reliable, measurements of r-f voltage developed across a resistive dummy load may be used in conjunction with the measured characteristics of the transmitting radiator. The attenuation tolerance recommended is that the field strength so measured be down at least 20 db from the 100-kc value at values lower than 1.25 Mc and higher than 4.5 Mc from the carrier. Within the sideband regions, the characteristic is to fall not more than 2 db up to a modulating frequency of 1.25 Mc and not more than 6 db up to a frequency of 3 Mc. In the low frequency range it is recommended that the variation in transmitter

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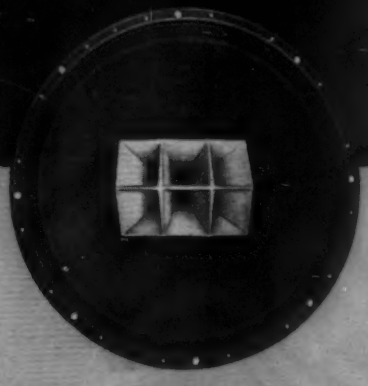

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output from frame to frame be not more than five percent, due to all causes, including hum, noise and low-frequency response.

The peak power output of a transmitter is defined as 1.73 times the average power measured in a resistive dummy load (resistance equal to the transmission line) when the transmitter is transmitting a standard black television image. Various definitions of rated power, maximum peak power, and operating peak power are stated. The carrier frequency stability recommended is plus or minus 0.005 percent, compared with 0.01 percent required by the FCC at present. Finally, it is urged that the esr (effective signal radiated) now used by the FCC as a basis for licensing television stations, be dropped in favor of a more complete specification of transmitter coverage shown on a contour map.

In conclusion, it is appropriate to quote the RTPB Panel Report, which expresses the unanimous opinion of members concerning the validity of the proposed standards and their suitability for immediate postwar use:

"It is understood that expansion of commercial television activity must await availability of materials and personnel. Prior to the resumption of full-scale operations it is important that the proposed standards be periodically re-examined in the light of technical developments. Panel 6 agrees that the proposed standards are the best on which to resume television activity, based on all presently available information, and, moreover, Panel 6 agrees that the standards do not in any way restrict the use of classified developments now individually known to the Panel and its Committee members."

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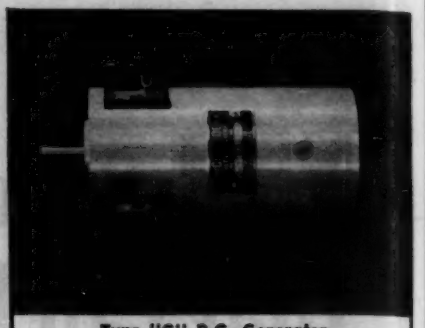

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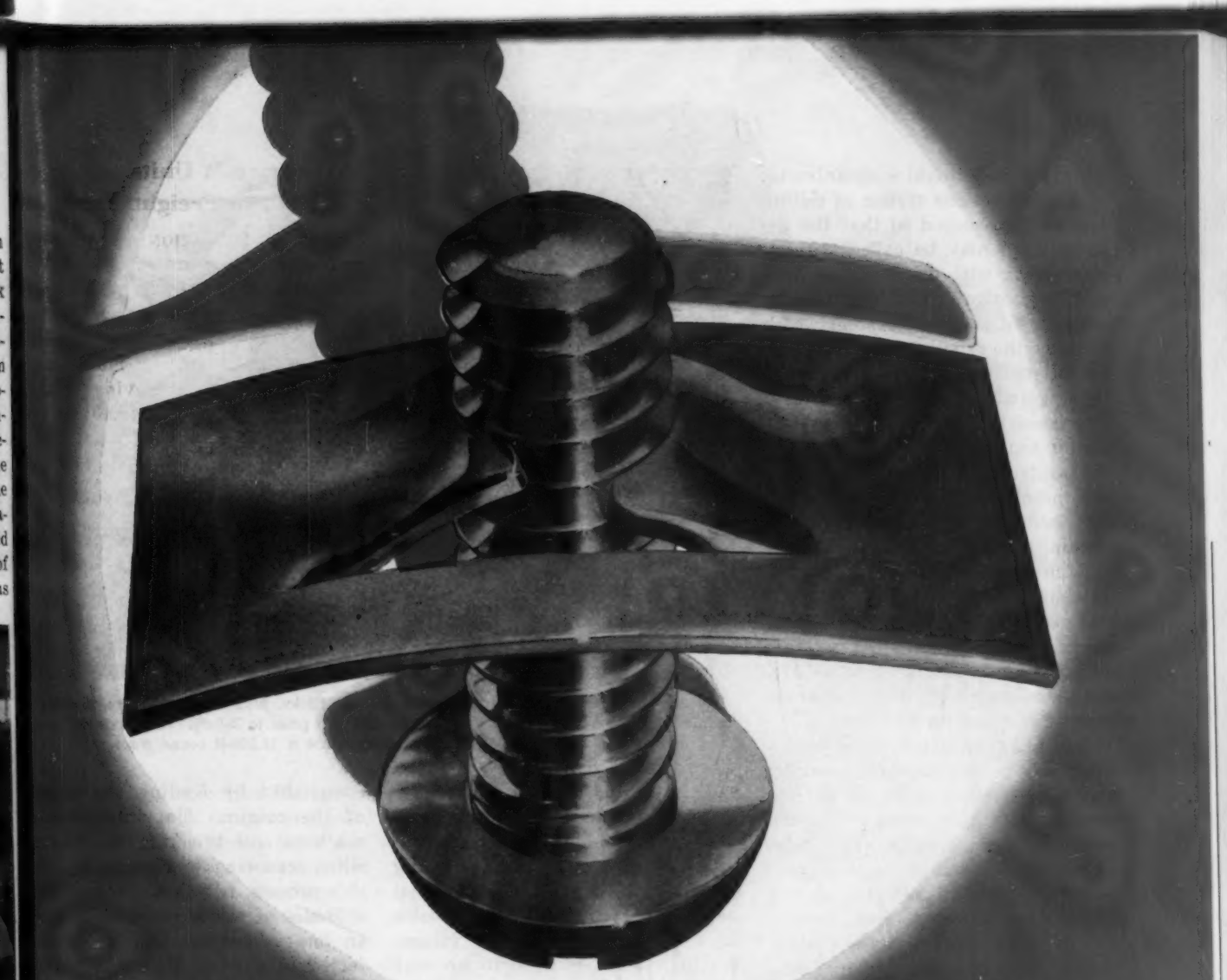

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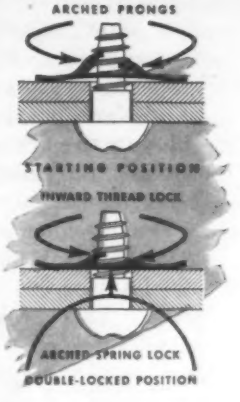

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TUBES AT WORK

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New Film Recorder in Invasion 176
Blind Landings with Electronic System 176
Quick Neutralizing Tests 188

Convenient Remote Amplifier

By ALVIN H. SMITH
Chief Engineer KSCJ

MANY BROADCAST STATIONS have need of an inexpensive single channel remote amplifier for convenience in handling remotes. Such an amplifier has been in daily service at KSCJ for over a year and has proven quite satisfactory.

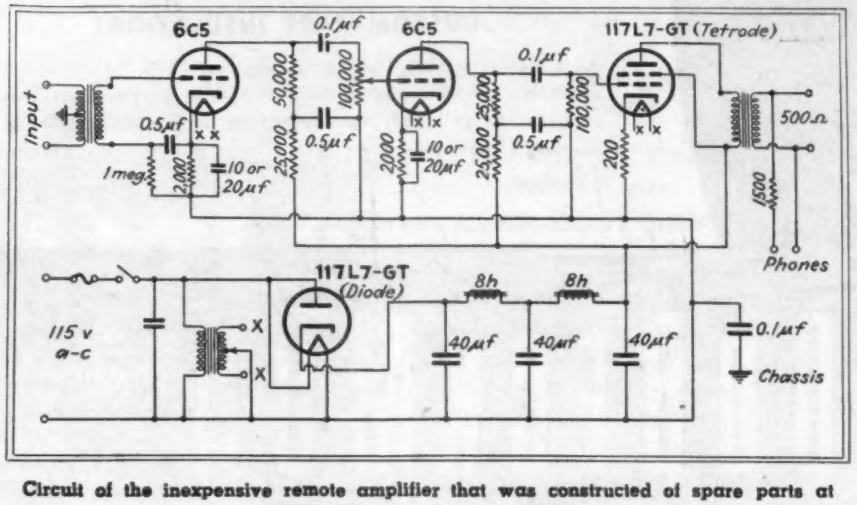
The manner of solving the problem of maintaining a low noise level, due to the proximity of the power supply to the low-level high-impedance audio circuits, will be of interest to other engineers.

Only one a-c transformer is used, a low-wattage 6.3-volt filament transformer. This is mounted as far from the microphone input transformer as possible, and positioned for minimum a-c pickup in the input transformer. The latter transformer has more effect on hum than any other single item in the amplifier.

To keep the filter chokes well away from the audio-frequency circuits, they were mounted on the opposite side of the chassis from the a-f transformers. All high-impedance leads were kept very short or completely shielded. The shells of the 6C5 tubes were grounded to the chassis to prevent oscillation.

An ideal output transformer was not available, so an inexpensive public address type transformer was used. This did not provide the proper loud impedance for the 117L7-GT but, due to the low power output required, this was found to be unimportant. Distortion is reduced somewhat by omitting the cathode bypass capacitor on the output stage to introduce degeneration.

The frequency response was found to be plus or minus 2 db from 50 to 17,000 cps. At voice frequencies, the distortion was approximately 1 percent with 6 milliwatts of output. The noise level was found to be down 55 db from a reference level of 6 milliwatts. while the overall gain was 90 db.



Circuit of the inexpensive remote amplifier that was constructed of spare parts at KSCJ. The overall gain is 90 db

Two-Way F-M Units Installed in Freight Yards

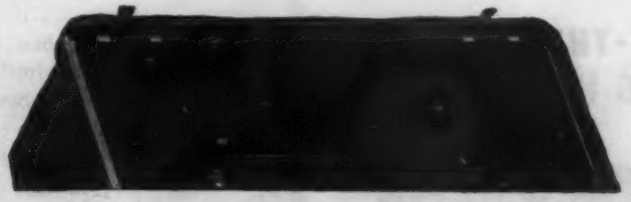
F-M COMMUNICATION between trains was inaugurated June 5, at the freight yards of the Rock Island Lines in Chicago. The installation consists of two locomotives equipped with portable f-m transmitting and receiving equipment and a master control unit incorporating transmitter and receiver at the freight yards at Blue Island and interconnected with the incoming and outgoing freight stations. The equipment is used primarily to increase efficiency of operation and speed up service as well as to minimize delays in the routing of freight traffic.

On approaching the railroad yards, train crews can now receive instructions from the train dispatcher via Motorola f-m equipment mounted behind the engineer

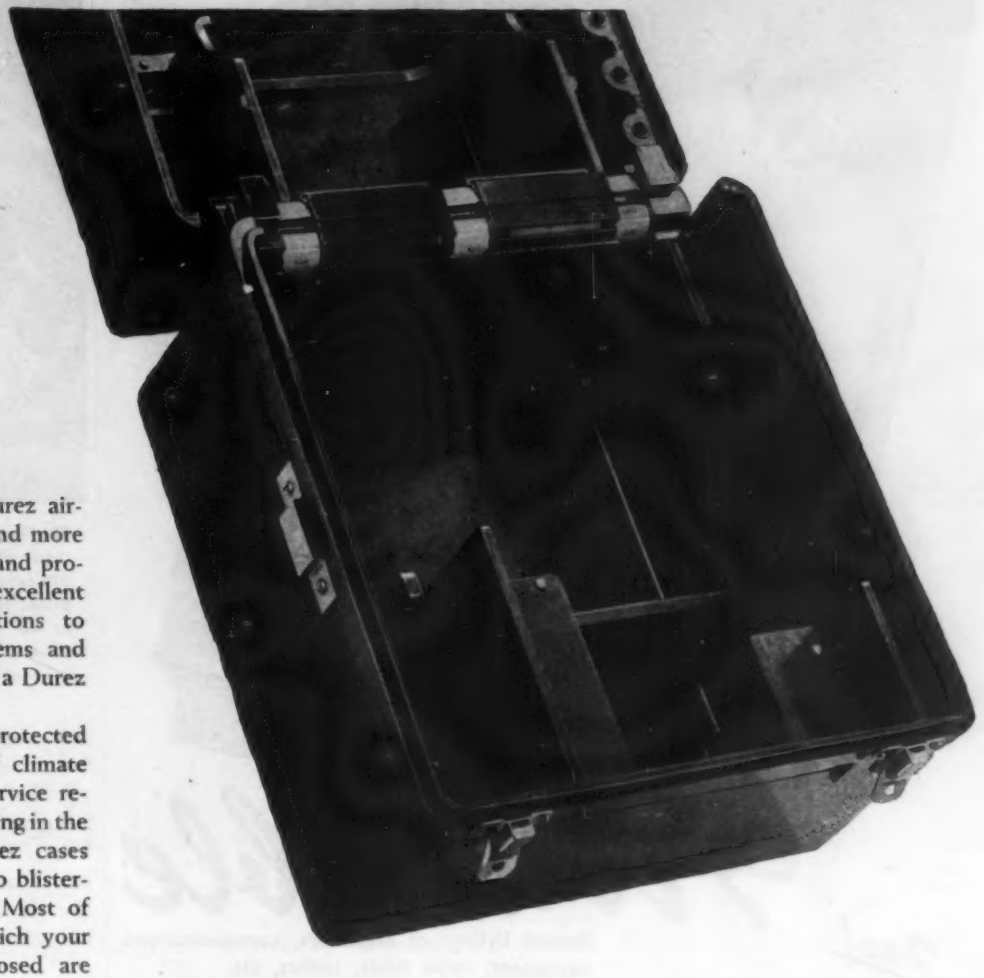
The f-m radio equipment used is fundamentally that described on page 102 of the January 1944 issue of ELECTRONICS, and manufactured by the Galvin Mfg. Co. of Chicago. Several modifications have been incorporated in order to adopt the Motorola standard unit for train use.

Technical Features

Provision is made to communicate by means of a hand telephone set, while a loudspeaker is used for calling purposes. Wire telephone links from two freight yards connect with the master radio control unit and thence by radio links to either of the two radio-equipped locomotives. The master control equipment is located at the base of a 90-ft lighting tower which sup-



How to find a dozen ideas



They're all in this molded Durez aircraft sextant case...a dozen and more ideas for designers, engineers, and production men. The case is an excellent example of ingenious solutions to very difficult molding problems and of the reasons for specifying a Durez phenolic.

Sextants, of course, must be protected from the bitterest moods of climate and geography. As far as service requirements go, almost everything in the book is thrown at these Durez cases — from salt spray and fog to blistering heat and freezing cold. Most of the service conditions to which your own products may be exposed are probably part of the daily life of the sextant case.

Versatility is the outstanding property of Durez. Check off a few of its characteristics. There's light weight, yet tensile strength is very good. There's impact strength which can take plenty of punishment. There's the fact that extreme temperatures affect neither inherent properties nor dimensional stability. There's powerful resistance to the corrosive attacks of chemicals, oils, mild acids and alkalies. And, there's a series of electrical properties which make Durez a first choice for that industry.

In the versatility of Durez may lie at least part of the answer to your production and merchandising problems. For instance, ease of moldability, another characteristic of Durez compounds, provided part of the answer to the highly complicated molding problem of the sextant case. We suggest that now is the time to start talking it over with your custom molder. And we are always ready with valuable data and personal assistance in answering plastic materials questions. Write to Durez Plastics & Chemicals, Inc., 88 Walck Road, North Tonawanda, New York.

DUREZ

PHENOLIC MOLDING COMPOUNDS AND RESINS

PLASTICS THAT FIT THE JOB

ports a conventional whip antenna.

A selective tone system of calling has been developed so that the desired train may be called without interfering with other radio-equipped locomotives. This operates by means of a resonant system which actuates the relays in the appropriate locomotive when the call system is actuated at the freight yard. Provision is made for calling any one of ten locomotives at will and the system may be expanded for any number of units. All radio-equipped trains can be called for a general broadcast.

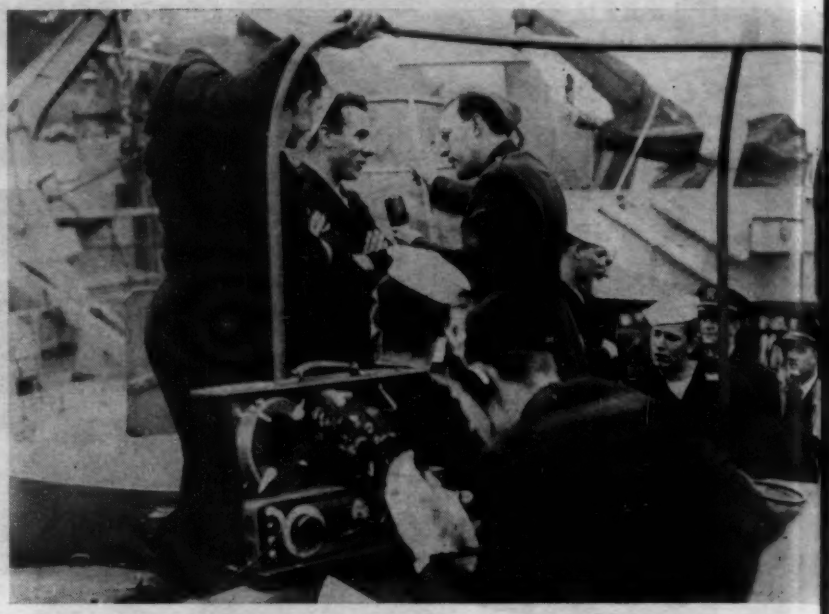
Each locomotive contains a whip antenna, loudspeaker and hand set, f-m receiver, f-m transmitter, and power generating units. At present, all communication is at 39.95 Mc, but plans are under way to operate about 250 Mc after the war.

Another application of f-m equipment which was demonstrated by the Rock Island Lines is an f-m system for duplex operation in the event of failure of railway telephone lines. In operation, one portable radio unit is used at each end of the line where a break occurs. Provision is made for feeding audio energy from the telephone line into the radio unit. Two such units replace the damaged wire circuits and permit an operation over a distance of 15 miles. Operating under the call letters KBPK on frequencies of 30.66 and 39.54 Mc, this duplex equipment has already seen useful service when storms damaged wire communications facilities.

New Film Recorder in Invasion

THE NOW FAMOUS BROADCAST by George Hicks, Blue Network correspondent, (an eyewitness account of a Nazi aerial attack on Allied ships in the first stages of the invasion) was made on a recorder using 35-mm movie film.

The machine embosses a sound track on blank film and can record 120 lines across the width of the strip. This provides a 12,000-ft sound track on a 50-ft film, about five hours of steady recording. The embossing is made with a sapphire stylus mounted in a magnetic head that presses against the film when it is supported by a resilient pad. A second sapphire in a magnetic head is used for playback.



The movie film recorder in action with George Hicks, Blue Network correspondent, while he interviews Navy men aboard an LST just prior to D-Day. The recorder uses both sides of a 50-ft film to accommodate a 12,000-ft sound track

An important feature of the machine is that starting and stopping are controlled by either a manual switch, electrical impulses or voice or sound. An automatic volume control circuit is used to prevent overmodulation and resultant overlapping of the sound grooves. Made by Amertype Recordgraph Corp. of New York.

Censoring of Hicks story was accomplished by feeding the outpu of the original film into anothe machine and breaking the circui when censoring was necessary. I this process, it was discovered tha syllables of words could be delete In one recording, the censor o jected to a word that was plura The next word was singular, but t form a sentence it had to be plura so the sibilant sound of the 's' w taken off the first word and put o the second word.

Blind Landings with Electronic System

AN INSTRUMENT which permits pilots to make blind landings on runways within fifty feet of a preselected spot is now being built into combat planes and trainers. The instrument, shown in the photographs, is used as the indicator of an electronic system that is the result of seven years of continuous research and development by Westinghouse Elec. and Mfg. Co. and the Washington Institute of Technology, which worked with the U. S. Navy to originate a simplified device for taking the guesswork out of blind landings.

In the electronic system, the pilot gets all directions for descent by watching two crossed pointers and two signal lamps on the instrument. These are actuated by two radio receivers in the plane which are tuned to the directional beams transmitted by the grou equipment. One receiver respon to the localizer, or on-course bea and moves the vertical pointer the instrument dial. The seco receiver responds to altitude si nals and operates the horizon pointer.

Transmitters

Four radio transmitters and t antenna systems at and near t airport comprise the ground ra equipment. These produce bea which first indicate the pilot's a proach to the field and then ma the field's boundary; establish t invisible glide path which leads the runway; and signal directio for keeping the glide to the fi neither too shallow nor too ste

Vertical guidance is provided three of these transmitters. O

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furnishes the glide path, a radio beam similar to the funnel-shaped ray thrown by a flashlight. The other two transmitters are markers whose beacon signals, transmitted vertically, light the lamps on the instrument panel via the plane's marker receivers. The first flash

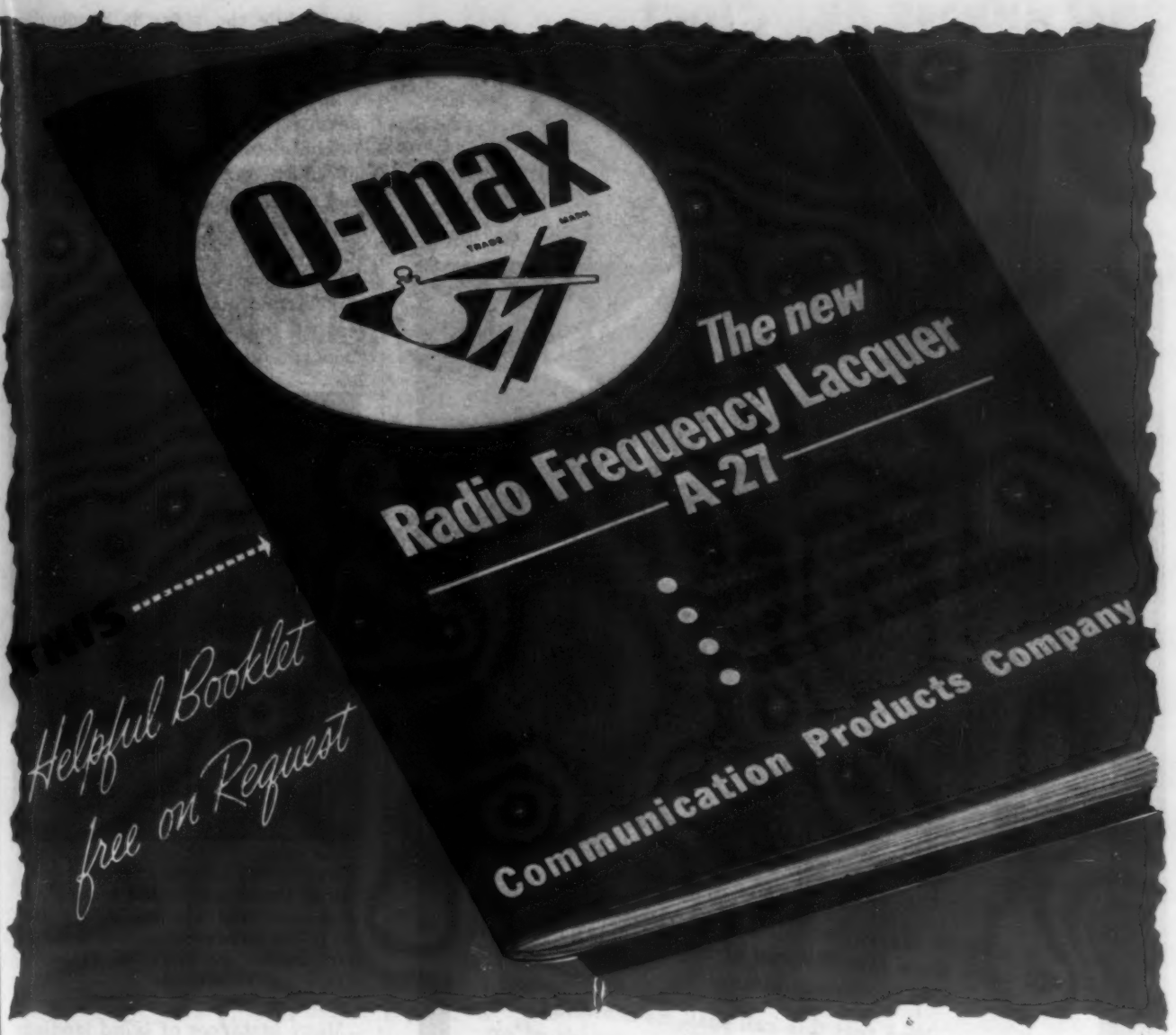
The two crossed pointers on the instrument above the control post remain in alignment with dotted lines on the panel face as long as a pilot's descent to an unseen runway is precisely on course. Signals from transmitters on the ground actuate the pointers

tells the pilot he is a few miles from the airport and that he should prepare for the glide path by maintaining an altitude of 1500 feet. When a similar beam from the second marker lights the other lamp, the pilot knows he has reached the boundary of the field.

Operation

The homing path, or localizer, is produced by ultrahigh frequency radio transmitters feeding two sharply directional loops. Signal strength emanating from the loops is almost equal if the plane is on course and flying in directly between them. This the vertical pointer of the instrument interprets by assuming an upright position. Should the plane wander to the left or right of the course, the corresponding signal predominates and the vertical pointer veers in that direction in an amount roughly proportional to the distance the ship has flown off course.

The horizontal pointer remains in position across the center of the



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dial while the plane is descending at the correct angle. If the glide is too shallow, the pointer rises; if it is too steep, the pointer moves downward.

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They reached the alternate field after nightfall, and were compelled by dwindling gas supplies to make short work of their landings. The indicator guided them quickly and precisely down to a base unknown to them, amid rough, dangerous terrain. Landing there without aid of the indicator might have been disastrous.

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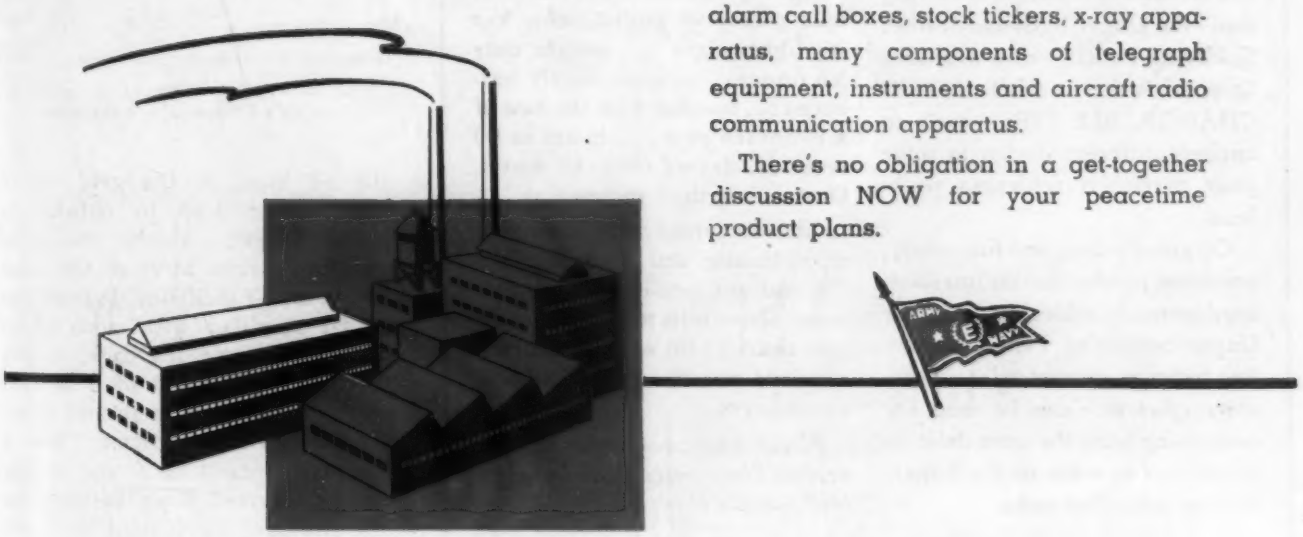

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Quick Neutralizing Tests

By JOSEPH ZELLE
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TRANSMITTERS that are on the air for long pediods of time, or continuous 24-hour operation, can be checked for neutralization while operating. This is accomplished by the simple expedient of tuning the plate controls slightly off resonance and observing the action of the grid meters. This procedure is based on the assumption that the circuit is operating as a pure amplifier, with the deviation from normal readings indicating some irregularity. It also assumes that the Q of the circuit is constant over the tuning range. Theoretically the Q is constant for only one frequency in a given circuit; however, for this small tuning change the Q is virtually the same.

Figure 1 illustrates the condition under investigation while tuning the r-f amplifier. At *A* is a block diagram of a neutralized amplifier,

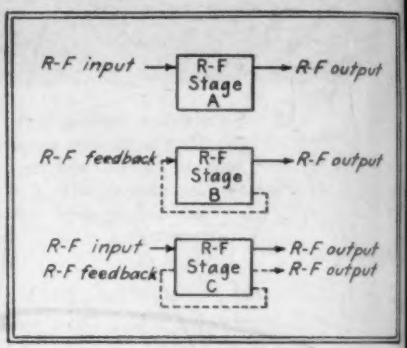

FIG. 1—Typical conditions of operation of an r-f stage in a transmitter

the r-f input to the grid circuit alone being used to obtain the power output. Almost the same condition exists at *B* of the same figure, an r-f oscillator. It is merely an r-f amplifier with some of its own plate power fed back, usually in the neighborhood of 5 percent of the output and in proper phase for sustained oscillations. Thus in the grid circuits of *A* and *B* only one r-f current flows to vary the bias voltage. In *C* of Fig. 1, we have the case of the unneutralized amplifier, where r-f is fed from a preceding stage, but some r-f is also fed back from a spurious frequency in the plate circuit. This is really a combination of an r-f amplifier and an oscillator that results

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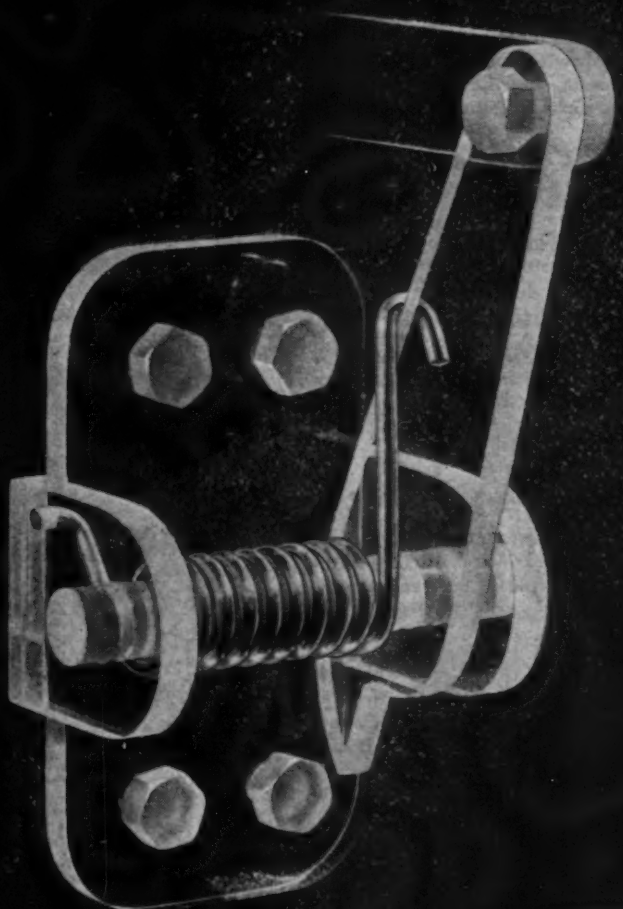

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not only in poor efficiency but pr
duces undesirable frequencies.

With cases illustrated at *A* a
B, an ammeter in the grid circ
will show the current flowing d
ing resonance, and this current w
fall off in about the same degr
either side of resonance, as illu
trated by curve *AA* of Fig. 2.

Some operators prefer to wat
plate and grid ammeters at t
same time, the one rising and t
other falling about the same degr
either side of resonance. Howeve
in tightly coupled circuits, esp
cially at high frequencies, these t
relationships may not hold ev
though the amplifier is perfect
neutralized.

Instability

When another current is prese
in the grid circuit due to extraneo
oscillations, the current will not f
off at the same angle, but one si
will have a steeper dip than t
other. Thus, if in tuning from
to F_1 and F_2, the curve AC result
and may be an indication of unb
ance, possibly caused by bad ne
tralization. Curve AC might in

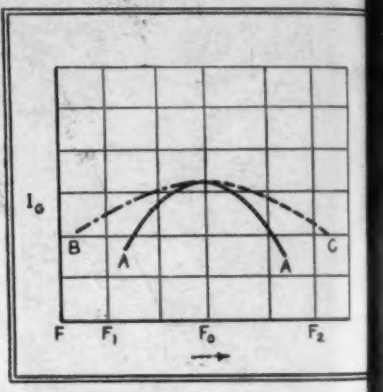

Fig. 2—Graph showing the possible changes in grid current of an r-f amplifier when the plate tank circuit is tuned through resonance

cate instability at frequencies abo
resonance, which would call for r
duction of inductance (in indu
tance neutralization). Curve B
would show possible instability b
low resonance, requiring more i
ductance or capacitance in the ne
tralization circuit.

While this system may indica
an unbalance in the tank circuit,
is not to be used to obtain neutra
ization. Even if an unbalance
noticed, it is no assurance that t
circuit is not neutralized. Furthe
more, only operators thorough

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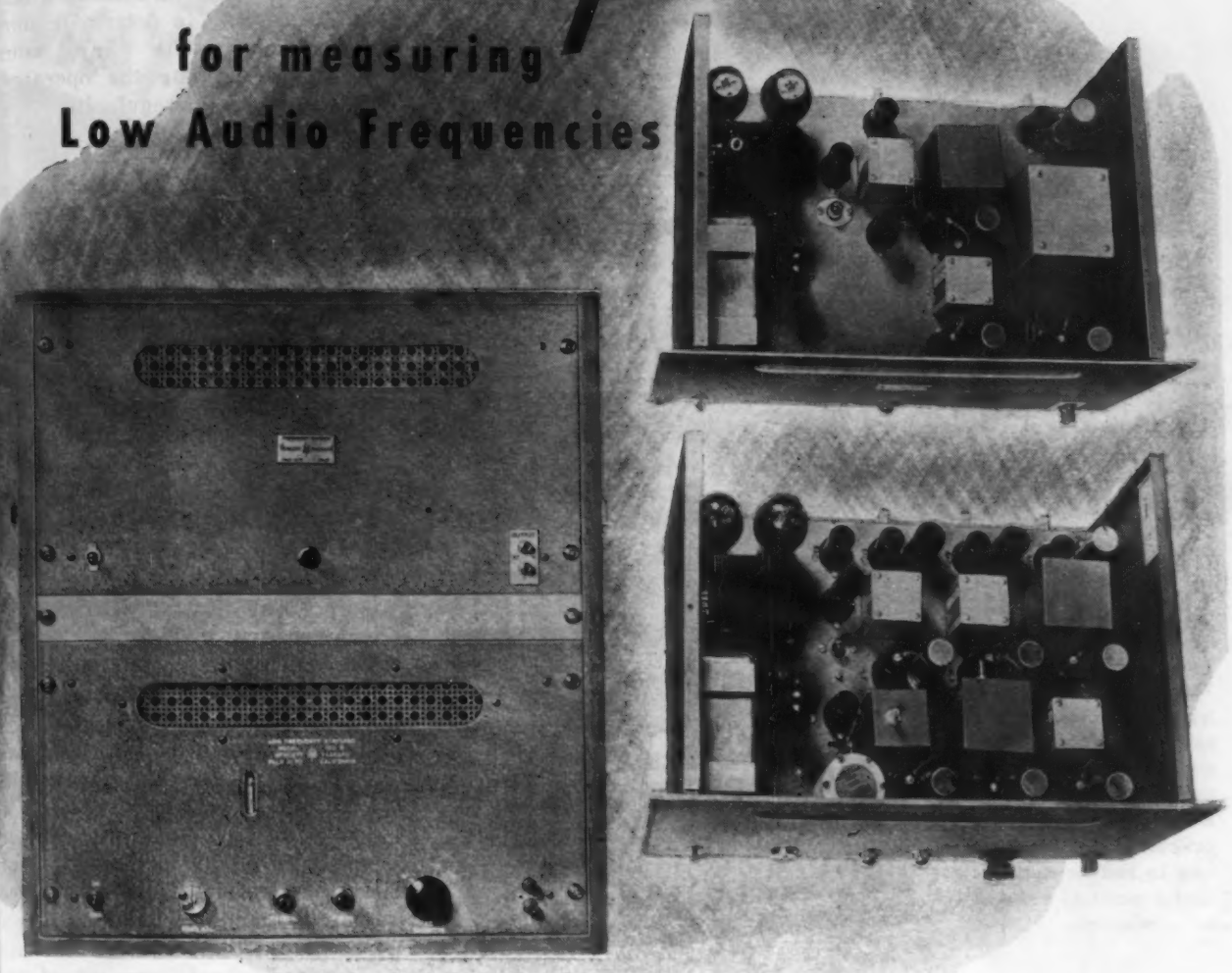

The problems of measuring low frequencies usually require a great deal of flexibility in instruments and in such work it is generally desirable to make measurements by lissijou pattern method. *-hp-* offers a simple solution to such problems with the model 100B Frequency Standard in conjunction with a 10 cycle frequency divider. This combination (illustrated) will give an output of 10, 100, 1000, 10,000 and 100,000 CPS with accuracy within plus or minus .001%. To provide a large number of harmonics for measuring frequencies above 100KC, generators and mixing panels can be supplied. These additions will provide the means for measuring frequencies up to 50 megacycles. *-hp-* can also supply standardization and measurement equipment for much higher frequencies.

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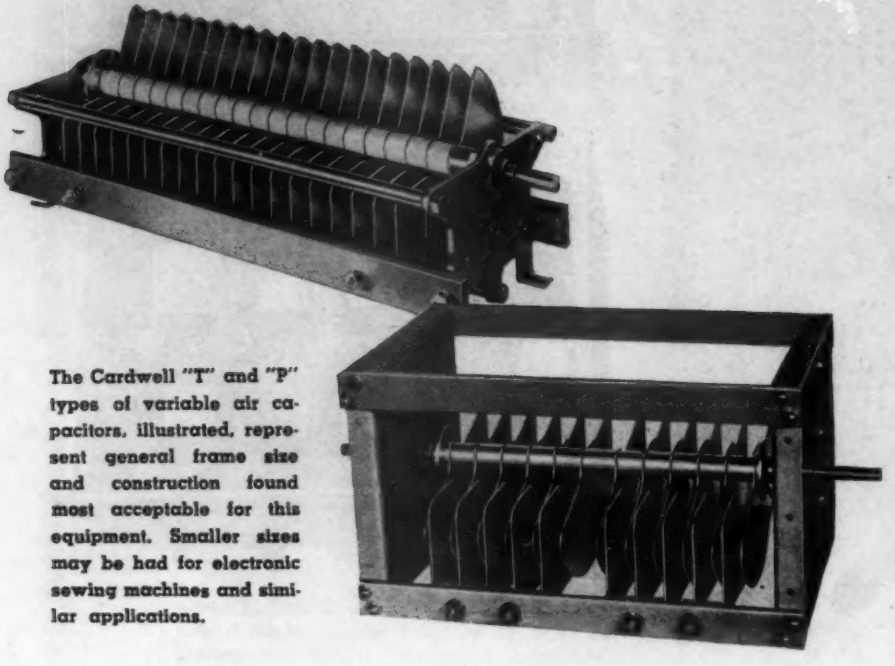

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familiar with their transmitter should use this method, since off-resonance operation can raise the plate current to the point where the overload circuits would operate. It would then be difficult to bring controls back to normal to get the transmitter back on the air. Observing the grid ammeters should be used only to determine normal conditions, with any unusual changes warning the operator of some kind of irregularity.

Another Method

Another way of checking neutralization rapidly is by cutting off excitation. (This may require a recording of a carrier break in the transmitter log.) This is done by shutting off the auxiliary oscillator's plate supply and then switching the oscillator transfer switch to the dead oscillator, killing r-f to all succeeding tubes. If the tubes are all biased to cut-off or beyond, the grid and plate ammeters should all drop to zero in a perfectly neutralized transmitter and the carrier should go off the air. Any flow of plate and grid current will indicate possible oscillation in the earliest stage and should be checked through regular neutralization procedures.

This process of checking takes only a couple of seconds, long enough for the technician to observe that the particular ammeters read zero, while plate and grid voltmeters remain at normal readings. Amplifiers with self-bias are so biased that, with all excitation removed a safe amount of plate current flows. Such a stage would seem to have regeneration or oscillation, but the skilled technician will be familiar with his circuits.

Where plate current flows with excitation off, the difficulty may be traced not only to improper neutralization but to spurious oscillations, caused generally by similar r-f chokes resonating in the plate and grid circuits at some far removed low frequency. Parasitics of high frequency due to long r-f leads may also cause irregular operation and may show up with this check.

Checks After Shutdown

If the operator has more time available and his transmitter is off the air he has two other easy ways

LOOKING FOR A HIGH VALUE OF...

WATTS PER OUNCE?

This Little Giant Has It, And At 200 Mc, Too!

Imagine getting 90 watts continuous output* from a tube that weighs only 1.5 oz. and at 3 meters! Even at 1.5 meters (200 Mc) the output is still high, 65 watts. A couple of years ago such a tube was a dream, now it's a reality. In spite of its small size and weight, GENERAL ELECTRONIC'S DR-24G triode is conservatively rated. Its superb performance results from the teamwork that goes into its manufacture . . . teamwork of design engineers who give careful attention to details and skilled hand craftsmen experienced in precision glassblowing and in the other steps of production and testing.

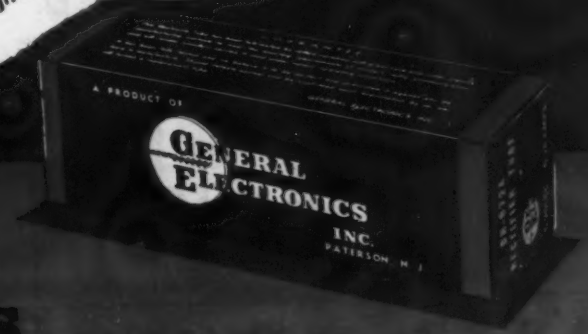
There are no insulators or supports here to evolve gas on the first overload, no exposed filament to spray the envelope with energy-wasting electrons. The plate dome is just one of those details which distinguishes the DR-24G. A tantalum plate and grid eliminate the flashed-film type getter and allow the tube to run cooler, particularly at high frequencies.

TECHNICAL DESCRIPTION

Filament..Thoriated Tungsten	
Volts	6.3
Amperes	3.0
Max. Plate Voltage	
100 Mc	2000 v
200 Mc	1500 v
Max. Av. Plate Current	75 ma
Max. Av. Plate Dissipation	25 w
Max. Av. Grid Current	25 ma
Amplification Factor	25
Capacities	
Grid to Plate	1.7 uuf
Grid to Filament	2.5 uuf
Filament to Plate	0.4 uuf

4⅜" Overall Height, 1½" Diameter
Nonex Glass Envelope
Base Standard Small 4 prong

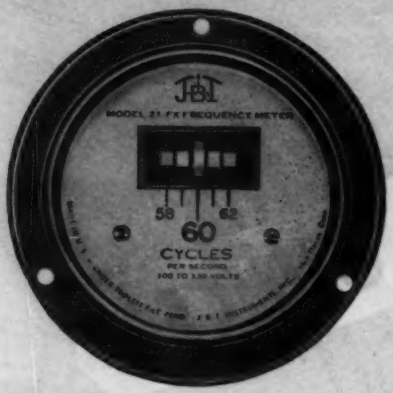
* As a Class C, Unmodulated UHF Amplifier



GENERAL ELECTRONICS INC.
101 HAZEL STREET, PATERSON 3, N. J.

SALES OFFICE, NEW YORK 23, 1819 BROADWAY EXPORT DEPT., 85 BROAD STREET, NEW YORK 4, N. Y. CHICAGO 47, 1917 NO. SPRINGFIELD AVE.

How to Read a VIBRATING REED FREQUENCY METER in 1 Easy Lesson!



ON THE NOSE! Model 21-FX, full cycle increment, shown indicating a frequency of 60 cycles. The 60 cycle reed is vibrating to full amplitude with the adjacent 59 and 61 cycle reeds practically at a stand still.

for example:

60.5 cycles. The 60 and 61 cycle reeds are vibrating equally, but to less than full amplitude. Side reeds are quiet.

60.75 cycles. The 60 cycle reed is vibrating a little, and the 61 cycle reed is vibrating to almost full amplitude. Other reeds are quiet.

60.75 cycles. Note this is a half-cycle instrument. The 60.5 and the 61 cycle reeds are vibrating equally.

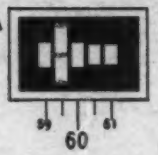
24.85. Watch the scale! Each division is one half cycle. Frequency lies between 24.5 cycles and 25 cycles and closer to 25 than 24.5.

118.0. This one is easy. Each division represents a full cycle. The 118 cycle reed has no competition in this example.

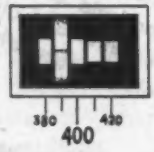
395. This is a cinch, too. How many cycles per division? Five—right. The 395 cycle reed has everything its own way, here.

Now, how good are you? Watch your Scales!

A



B



C

SIMPLY READ THE REED

That's Your Frequency!

Bulletin VF-43 with supplements gives detailed descriptions of the complete line of J-B-T Frequency Meters. Your copy is waiting for you.

J-B-T

B-JBT-1

Answers, but NO PEEKING

A = 59.5
B = 390.0
C = 25.0

(Manufactured under Triplett Patents and/or Patents Pending)

J-B-T INSTRUMENTS, INC.

431 CHAPEL STREET • NEW HAVEN 8, CONNECTICUT

of checking roughly for neutralization. With the filament of the amplifier tube lit, but the plate voltage off, r-f voltage is fed to the amplifier. While observing the grid current meter, the plate tank tuning capacitor is rotated through resonance (with no plate voltage). In a perfectly neutralized stage, the grid ammeter reading should remain steady, since the plate circuit is supposed to have no reaction upon the grid circuit.

In a badly neutralized stage, there will be a violent dip of the grid meter while tuning through resonance. There will generally be some slight reaction on the meter, especially on the higher frequencies, even though the amplifier is neutralized, but the operator will easily recognize this flutter of the needle from the more pronounced dip caused by poor neutralization.

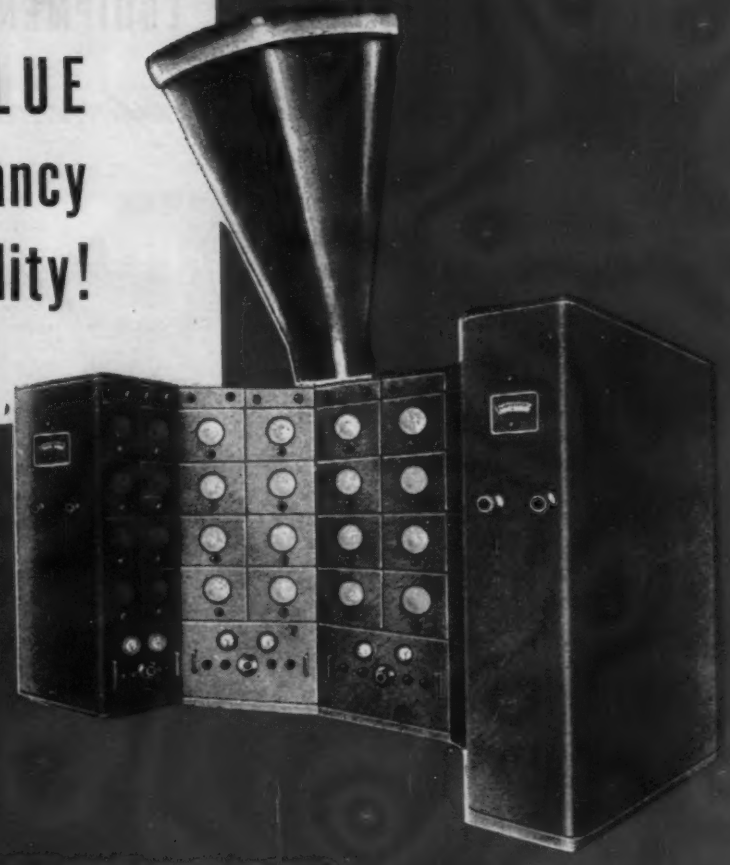
Another quick check is good for all but the final stage. This requires that two stages have no plate voltage while checking, although the filaments remain on. With a preceding stage tuned to resonance (but no plate voltage) the succeeding amplifier is likewise tuned to resonance and its plate meter observed for current. The presence of current will be a fairly sure sign of r-f leaking through the preceding amplifier tube and being rectified in the succeeding stage.

Obviously the final stage cannot be checked in this manner since there is no following stage by which to detect the presence of r-f. At higher frequencies or due to stray couplings, some r-f may still feed through but the engineer is conscious of these peculiarities.

Other Effects

It must be stressed that the technician must be fully acquainted with the circuits he tests by these methods, to avoid damage and trouble. These checks should serve to indicate that everything is operating normally, any deviations from usual readings only warning the operator for more careful checking. Even after these tests, there may be extraneous oscillations due to shock excitation, transients, or other strays developed by long operation of circuits, which will escape these tests. Such special conditions require treatment with extensive and elaborate equipment.

POSITIVE CLUE to Life Expectancy and Dependability!



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EQUIPMENT

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★ Front panel will match finish of cabinets.

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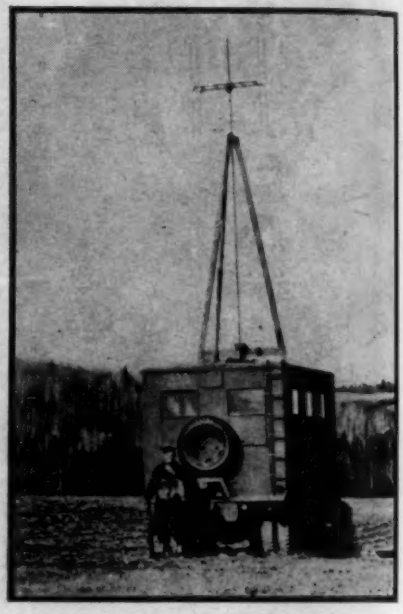
marker in a specified manner. The Z markers are also used to indicate clearance to the pilot to proceed to the next fan marker. When used in this way, the Z markers are used as traffic lights to indicate a clear air-passage on the next leg of the journey.

Combined Voice and D-F

While these facilities are useful in directing a plane, experience has shown that it is often desirable or necessary to talk to the pilot while he is flying a course. Early installations made provisions for such an arrangement by transmitting voice-modulation in place of the radio-range beacon signal. Such a pro-



AACS v-h-f direction-finder on wheels, used to guide fighter aircraft to emergency fields

cedure made it necessary to shut off the A-N signals when voice communication was desired. This was undesirable since it temporarily denied the homing device to pilots flying the course.

To overcome this objection, a simultaneous radio-range beacon was devised. This permits the operator in the control tower to speak to pilots in flight at the same time that the pilot makes use of direction-finding signals. Simultaneous radio-range stations are used to transmit weather data to pilots while flying, and to direct traffic near the control tower. Ordinarily, these simultaneous radio-range stations operate 24 hours a day except in

M-R

Friction and Sealing Tapes

M-R FASTHOLD FRICTION TAPE

Double Coated With Rubbery Compounds . . . Tensile Strength more than 44 pounds . . . Adhesive Strength more than 50 Pounds

In the manufacture of FASTHOLD FRICTION TAPE the best procurable cotton sheeting (long staple 56/60) is first dried to eliminate moisture . . . then the fabric is thoroughly impregnated with a filler coat of insulating, waterproofing and preserving compound . . . after several days of drying a second coat, exceptionally heavy in rubber content, is forced through the fabric by means of enormous rollers . . . then follows another period of drying out before cutting and wrapping in tin foil for protection.

The materials used and the precision and control exercised in the manufacture of FASTHOLD FRICTION TAPE enables it to meet all known electrical tests and requirements . . . and to Guarantee it against Unraveling or Drying Out.

FASTHOLD FRICTION TAPE is New York warehouse stocked in widths of ⅜—½—¾—1—1½ and 2 inches.

M-R ANHYDROUS SEALING TAPE

IMPROVES WITH AGE AND SERVICE

25.58% Cotton Sheeting
74.42% M-R Insulating Compounds

Weatherproof . . . Waterproof . . . Acid, Alkali, Oilproof . . . Permanently Flexible . . . Will not Vulcanize or Dry Out . . . Tensile Strength 30 Pounds . . . Dielectric 1,000 volts

ANHYDROUS SEALING TAPE contains nothing which will injure fabrics or metals. It is made of the best procurable cotton sheeting and special M-R Bituminous Compounds. A wrapping of ANHYDROUS TAPE gradually becomes one solid mass (glass hard on the outside and soft inside) that excludes air, moisture, vapors, etc. It can be used to great advantage under conditions which disintegrate ordinary tapes; inside work where acids or alkali fumes or spray prevail; outside for cable joint insulation in conduits, transformer connections, extreme high or low temperatures, etc.; mines and damp places where atmospheric conditions and constant friction demand maximum wearing qualities.

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ANHYDROUS SEALING TAPES are New York warehouse stocked in widths of ¾ and 1½ inches . . . other sizes are available, as ordered.

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Write today for samples of M-R Friction and Sealing Tapes . . . also your Free Card of Varnished Tubing with samples ranging from size 0 to 20 to fit wires from .032 to .325 inches . . . other valuable aids, are the M-R Guide Book of Electrical Insulation . . . the Wall Chart with reference tables, electrical symbols, allowable capacities of conductors, dielectric averages, thicknesses of insulating materials and tap drill sizes . . . and the M-R Wax and Compound Guide Book . . . they are full of valuable information . . . write for them on your letterhead.

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NEW radio developments are being worked out behind these new doors. ¶On the success of its past achievements Pacific Division's Radio Engineering Laboratory has earned for itself a greatly expanded workshop. ¶The same engineers who developed the Gibson Girl Emergency Transmitter . . . who pioneered in radio remote control equipment, now have the full facilities to accelerate their development work. Principally they are working on a new interpretation of simplified UHF for aircraft and other uses. The doors of this new laboratory will open tomorrow when this development is perfected.

Pacific Division
Bendix Aviation Corporation
NORTH HOLLYWOOD, CALIF.

Before Pearl Harbor Pacific Division developed the famous Gibson Girl Emergency Transmitter, which is now standard equipment on every A.A.F. and A.T.C. airplane making overwater flights.

combat zones. In such cases they operate only at the request of a pilot.

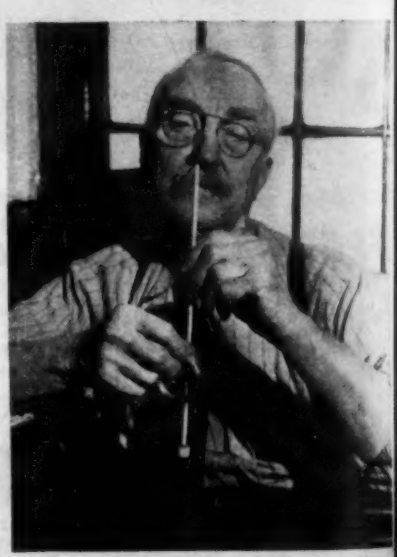
Direction-Finding Methods Provide Bearings for Pilots

While radio range-beacons are relied on as much as possible, these facilities may not always be depended upon. This is particularly true in combat areas where equipment may be damaged as a result of enemy action, where fighter pilots are not too well trained in radio range-beacon methods, or where blackouts may be encountered. In such cases, radio direction-finding methods are used to advantage.

Of course, bearings must be taken at several positions from transmissions sent out from the plane requesting its bearings. Bearings from several stations are then communicated to a central or key station where the position of the plane is determined. The plane's position is then communicated to the pilot. By taking sucessive bearings at various time intervals, the pilot can be kept advised of his position.—R.D.

• • •

SORTING PLATINUM WIRES IS FINE WORK



Platinum wires having diameters of 20, 22 and 24 thousandths of an inch can be sorted by sight and touch alone by 79-year old Warren Black. Employed by Brown Instrument Co., he hasn't been found wrong in 20 years by inspectors

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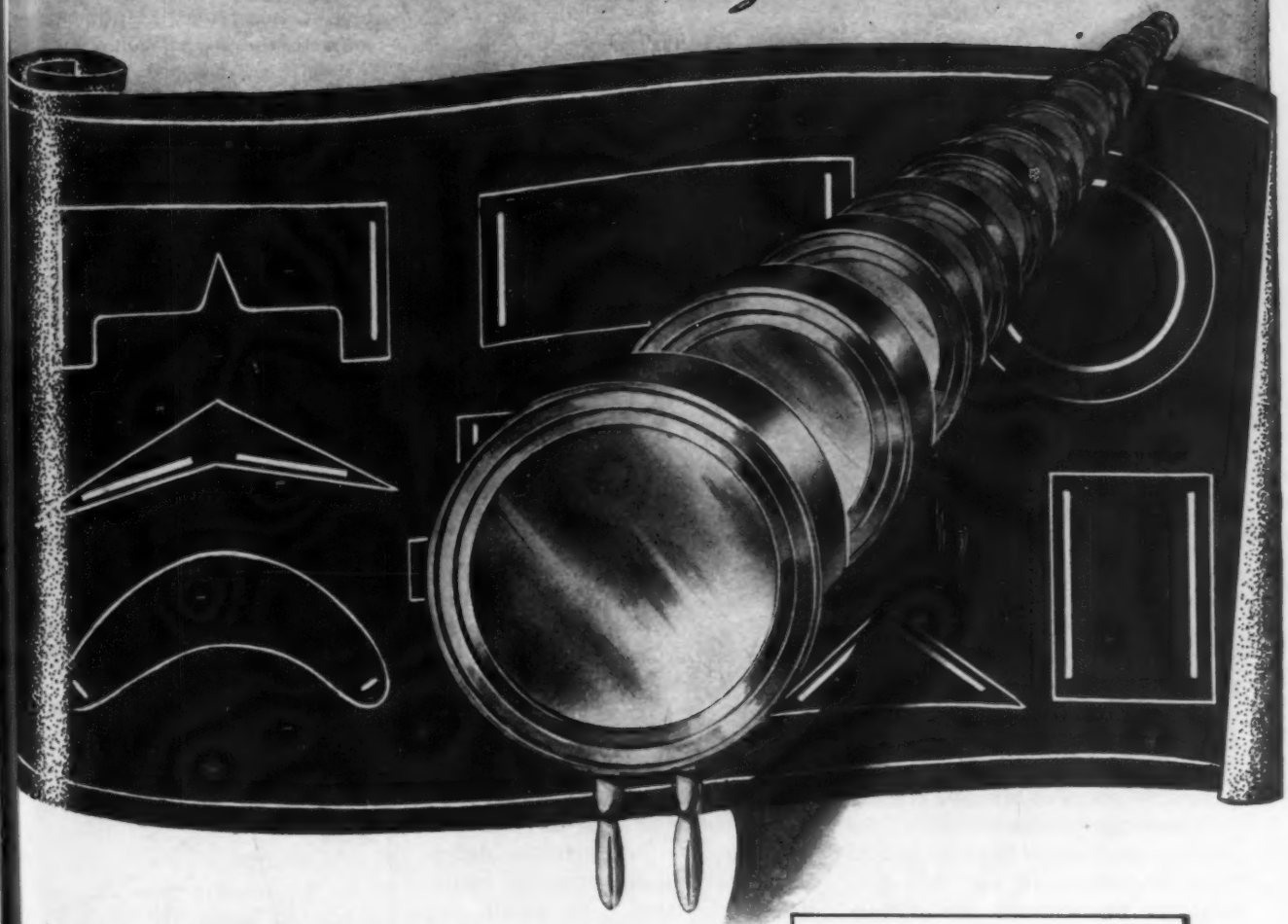

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THE ELECTRON ART

Infrared Spectroscopy in Industry 214
Radial Beam Tubes 214
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Infrared Spectroscopy in Industry

THAT THE USE OF INFRARED spectroscopy in industry has passed through its first phase in which the fundamental work has been done is pointed out in a recently published book, "Infrared Spectroscopy" by Barnes, Gore, Liddel and Williams, of American Cyanamid Co. (Reviewed in July, 1944 ELECTRONICS, p. 370) The authors review the preliminary work of spectroscopists in developing their own methods of quantitative analysis and suggest ways in which the new technique may be further improved as an industrial tool. A condensation of their views follows.

Industrial infrared spectroscopy is now entering its second phase—the development from proving potentialities under ideal research conditions to widespread applications under any practical conditions which might occur. It has passed the stage of hiring a trained infrared spectroscopist with the general instruction that he should build an instrument and then proceed to demonstrate its utility. Neither sufficient time nor trained personnel is available to permit such an approach. With the large number of companies now conducting infrared research, it is necessary that commercial spectrometers be available, that there be sufficient background information in the literature so that an operator may produce results immediately without spending a long time acquiring basic data.

The infrared spectroscopist already at work in the field was called upon to study the possibility of performing analyses which were difficult or tedious by chemical methods. Once a satisfactory analysis had been established, his research instrument was generally tied up for a month or more on routine work while research on further exploratory problems suffered. For his own protection, the spectroscopist developed simple, compact instruments having sufficient resolving power to handle the majority of the analytical problems encountered. With such instruments available, the role of the research spectrometer in analysis may be restricted to obtaining the pure spectra of the components involved. From these spectra, the analytical frequencies can be chosen and the rest of the analysis performed by means of the small spectrometer. For convenience in setting to these frequencies, mechanical stops are provided. These small instruments can be operated in the laboratory or moved to the site of the chemical reaction.

There are at least two important advances in the instrumentology of research spectrometers which must be made. Most infrared spectra are obtained today as records of frequency vs galvanometer deflection superimposed upon the radiation background. To obtain full significance from these results it is necessary to convert them to frequency vs percent transmission or log of percent transmission. This conversion now involves considerable tedious labor and it is highly desirable that the instrument make this conversion automatically. In short, infrared needs a spectrophotometer to replace its present spectrometer.

Most infrared recording is done by means of a very sensitive galvanometer amplifier. Unless the stability conditions of the building in which the instrument is used are favorable, such a mechanically sensitive device is not satisfactory. An improved detecting system is required and it is highly desirable that a means of electronic amplification of thermocouple output be devised to replace the present use of galvanometers. There is a growing tendency to use pen recorders rather than photographic methods for recording the galvanometer deflections. This means that an electronic stage must be interposed between the galvanometer beam and the actual record. If the entire amplification from the radiation detector to the record could be done electronically, the use of some type of a split beam instrument would answer the instrumental problems of the infrared spectroscopist.

Radial Beam Tubes

A NEW TYPE of vacuum tube, in which a flat radial beam of electrons in a cylindrical structure may be made to rotate about the axis, is described by A. M. Skellett in the *Bell System Technical Journal* for April, 1944. Features of the tube are its absence of an internal focusing structure and resultant simplicity of design, its small size, low operating voltage and high beam current.

Several designs and variations of the fundamental idea exhibited in this tube are possible. In its most elementary form, as illustrated in Fig. 1, the tube consists of a cylin-

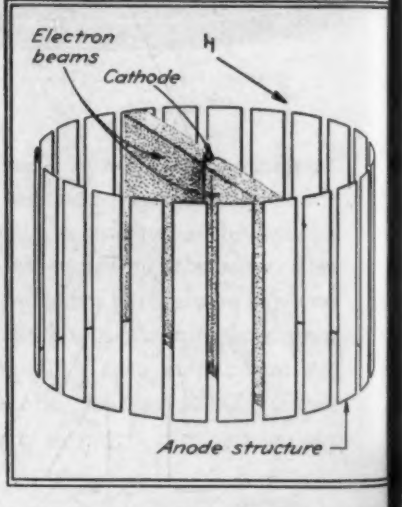

Fig. 1—Metal plates arranged cylindrically about the cathode form separate anodes in this new type of vacuum tube

drical cathode surrounded by a cylindrical anode structure which is divided into a number of parallel strips or separate rectangular anodes. When the potential of the

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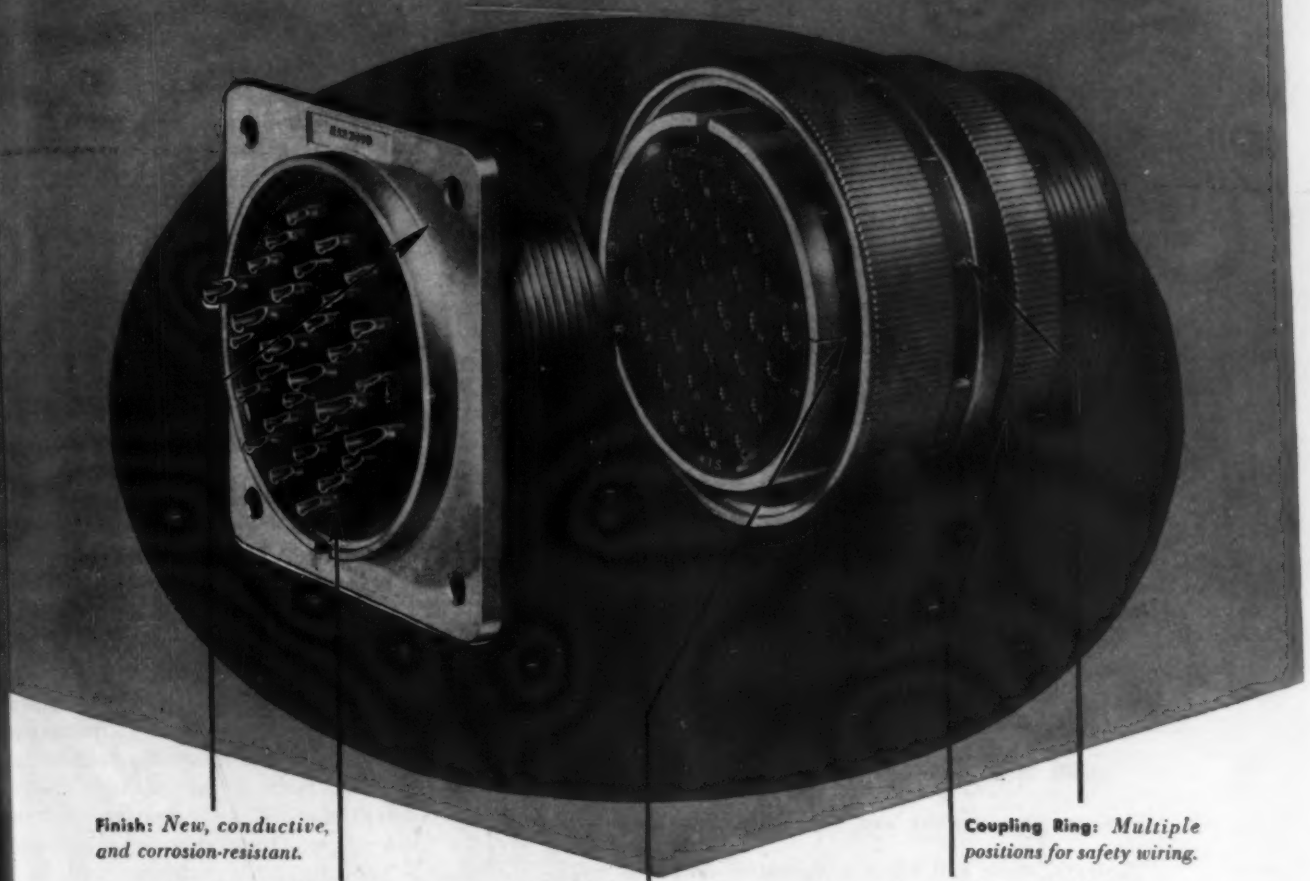

Finish: *New, conductive, and corrosion-resistant.*

Coupling Ring: *Multiple positions for safety wiring.*

Contacts: *Made of a new silver-clad material affording greater conductivity, and positioned for easier and faster fabrication.*

Split Shell: *Designed to facilitate assembly, inspection, and maintenance, with all the advantages of solid construction.*

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Harwood Connectors, constructed in accordance with Army and Navy Specifications Nos. AN-9534a and AN-W-C-591, have been consistently improved and simplified through progressive engineering, constant retooling, use of better materials, and rigid quality control.

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STOP "Leap-Frog" Corrosion

Federal Cathodic Protection Rectifier, Model FTR 5114-S. Output 20 amperes at 10 to 40 volts. Other sizes as required.

"Leap-Frog" Corrosion damages underground pipes and cables.

Pipes or other metal structures are in places electro-positive in relation to the soil and due to natural galvanic action corrosion results. Metal is taken away from one section of pipe and deposited somewhere else along the exposed pipe.

By using Federal Cathodic Protection Rectifiers, "Leap-Frog" corrosion is foiled. On constant guard is a direct current charge which cancels the harmful electrolytic corrosive action on oil, gas and water pipelines and underground cables.

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QUANTITY PRODUCERS OF STANDARD AND SPECIAL

Control Crystals

various anodes is made positive with respect to that of the cathode, electrons are drawn to each of these segments. When a uniform magnetic field is applied, with its direction at right angles to the axis of the tube, the electrons are focused in two diametrically opposite beams as shown, the direction of the magnetic field being indicated by the arrow marked *H*.

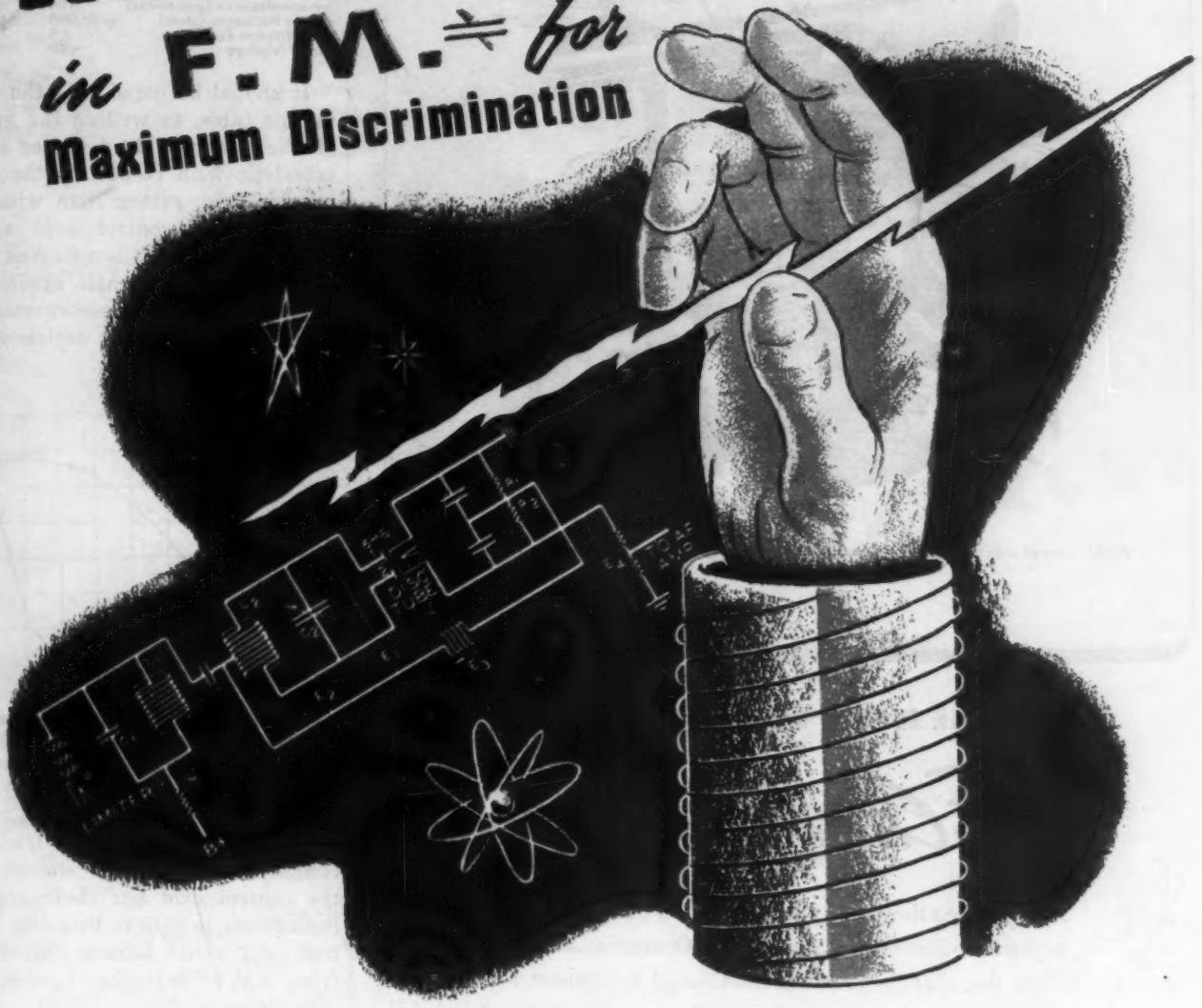
The beams are parallel to the lines of force of the magnetic field so that if the field is rotated the electron beams move around the tube with it. In this way, the magnetic field serves both to focus the electrons and to direct the resulting beams to different elements of the anode structure.

Single Beam

For some applications it is desirable to eliminate one of the two beams and this may be accomplished by substituting a uniform electrical field in the tube for the cylindrical field which results when all anode segments are at the same potential. The uniform field may be obtained by applying to the anode elements a series of potentials which vary according to the sine of the angle taken around the axis. The line joining the maximum potentials (+ and −) is maintained parallel to the magnetic field so that on one side of this cathode the potentials are all negative and the beam on that side is suppressed. The remaining beam will have somewhat less current than the corresponding one in the cylindrical field but the magnetic field strength required for focusing is reduced.

The magnetic field may be conveniently provided by inserting the tube in place of the armature in the stator of a two-pole polyphase alternating current motor. The rotation of the magnetic field in the stator of the motor determines the rotation of the electron beams within the tube. Permanent magnets may also be used for applications where the electron beams within the tube are not required to rotate continuously. A rotating field for the stator of the motor may be produced from a single-phase power supply by inserting a capacitor in series with each winding of a split single-phase stator so that the current through one phase

GUTHMAN *Discriminator* COILS *in* F. M. *for* Maximum Discrimination



FREQUENCY MODULATION receivers require linear discrimination against undesirable signals. Guthman engineers have developed precise **DISCRIMINATOR COILS** to discriminate equally on both sides of the resonance curve, providing maximum discrimination.

GUTHMAN *Leader in Inductronics*

DO YOUR BEST . . .
INVEST IN WAR BONDS!

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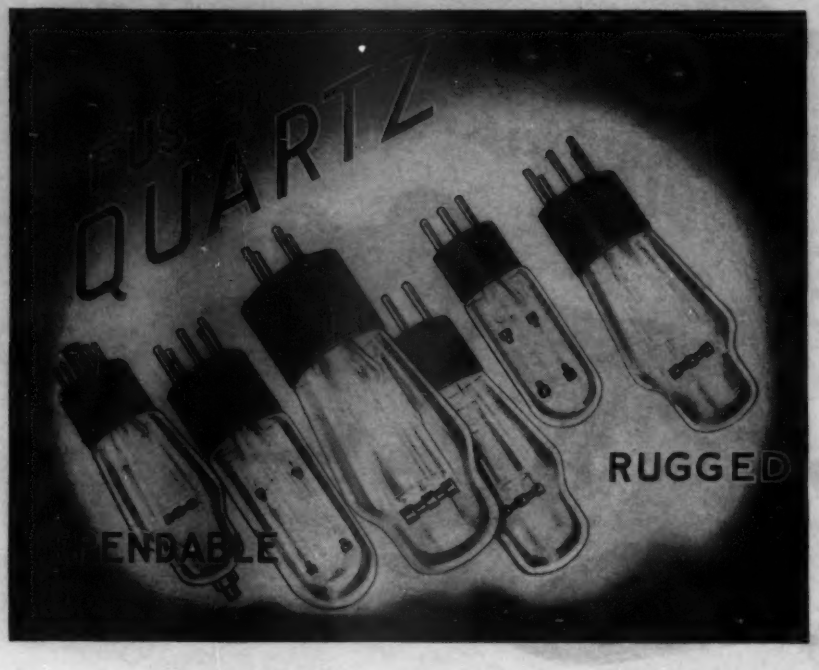

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winding lags by 45 deg and that through the other leads by an equal angle.

Construction

The fundamental principles used in this type of tube may be modified and elaborated, depending upon the application for which the tube is intended. The diagram of Fig. 2 shows the arrangement of the internal elements of a tube having 30 anodes and various auxiliary elements.

Surrounding the cathode is a control grid which modulates the electron beams in much the same way as any control grid. The cross-patched structure with 30 slots is maintained at a positive potential with respect to the cathode and is analogous in its operation to the screen grid of a tetrode or pentode.

Behind each window of the screen is a pair of paraxial wires which, because of similarity in function to the fourth element of a pentode, is called a suppressor grid. In back

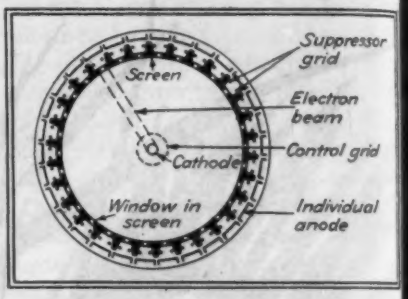

Fig. 2—This mechanical arrangement of electrodes permits a radial electron beam to be directed to each set of elements by a magnetic field

of each suppressor is a separate anode. Projection-like gear teeth in back of the screen elements are employed to prevent electrons, destined for one anode, from reaching an adjacent one.

As shown in Fig. 2, the screen consists of only one element. However, it may be split into a number of elements, if necessary to provide a separate screen for each individual anode. Likewise, the grid action of the suppressor grid may be increased by means of lateral wires across the window of the screen grid tube. The curves of Fig. 3 shows the characteristics of the tubes represented in Fig. 2. Curve B is obtained with lateral wires previously mentioned whereas curve A is obtained with simply the two

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paraxial suppressor grid wires. Measurements on this tube showed it to have the following characteristics:

	Without Laterals	With Laterals
Transconductance (micromhos)	100	250
Anode Resistance (ohms)	30,000	64,000
Amplification Factor	3.5	16.0
Cut-off Voltage	−80	−20

It should be noted that the data in this table, as well as the graph of Fig. 3 shows the transfer characteristic with respect to the suppressor grid, rather than with respect to the control grid as is usually the case. It is apparent that amplification of signals applied to the individual suppressors may be readily obtained. The article gives

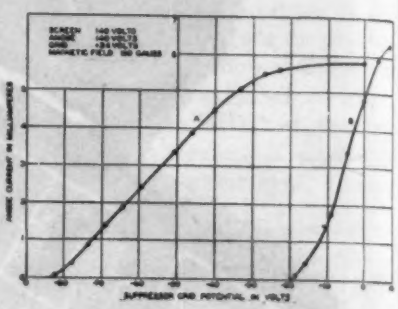
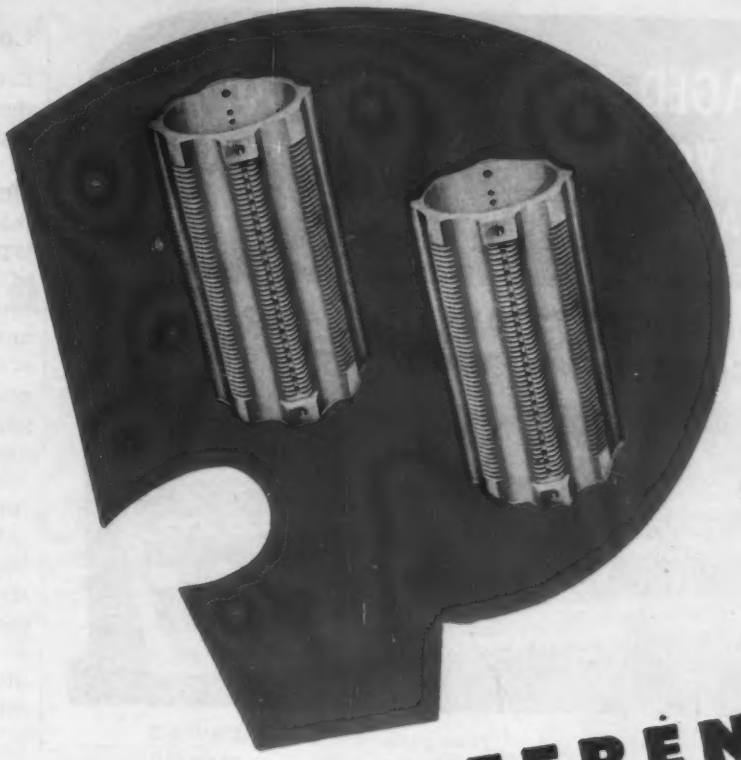


Fig. 3—Suppressor grid characteristics of the new tube. Curve *A* was obtained with lateral wires, curve *B* with lateral wires

no data concerning the transfer characteristics as determined by the control grid but there are no indications to believe that this control grid would behave differently from that of any other tube structure.

The article gives drawings and photographic reproductions of the formation of electron beams under varying magnetic fields and provides a mathematical analysis for the case of a cylindrical electrical field as well as a uniform electrical field.

While a tube of this general type should obviously be expected to lend itself to many useful and interesting applications, Dr. Skellett's article limits discussion to the use of this tube as an electronic commutator and the application of the tube to multiplex telegraphy. It is stated that a 30-channel multiplex system for signalling using two of the 30-anode tubes has been successfully tested over short distances in New York City.



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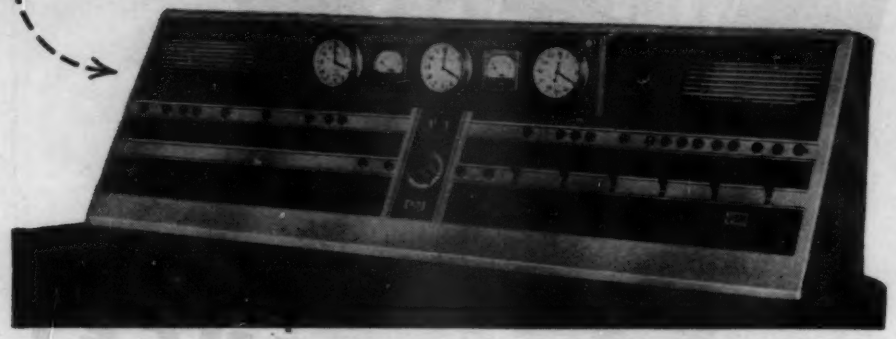

This radio control panel, 54" x 27" is a "prize package" of precision production and versatility—*76 accurately positioned, machined holes and slots, 3-tone enamel finish and color inlay, combination metal etching, a number of artistically produced escutcheons and bezels, and easy-to-read dials with sharply defined calibrations.*

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Control of Radium Poisoning

RECENTLY INTEREST has revived in the problem of preventing poisoning and other injuries from radium in plants engaged in painting luminous dials. This is a natural result of the great increase in this type of work for the manufacture of military equipment. Although the principles of protection are now well known, many new workers under foremen who have recently entered this field are engaged in applying radioactive paint and there is, therefore, an increased possibility of injury through ignorance.

In controlling this type of hazard, two important physical measurements are required. The radon content of the workroom air and of the expired breath of the individual workers must be determined. With these measurements, it is possible to ascertain whether the workroom air contains sufficient radon to constitute a hazard, and whether workers are taking any of the radium paint into their bodies.

Apparatus previously used for measurements of radon consisted of a sensitive string electrometer connected to an ionization chamber, in which the sample of air was placed to measure the strength of the ion current which the radon in the sample produced. This ion current is proportional to the amount of radon present. To save time, it was necessary to make this electrometer record its readings automatically. This required a special camera and the results were not known until the film was developed and interpreted. Many other disadvantages combined to reduce the rate at which tests could be made, such as failure of insulators in humid weather and the necessity for adjusting the sensitivity of the electrometer to the strength of each sample.

Electronic Method

To speed up these tests and also to improve their accuracy, a new method was developed by L. F. Curtiss and F. J. Davis and described in the September, 1943 *Journal of Research.* To make clear the principle employed, it should be explained that radon is a radioactive gas which emits alpha par-

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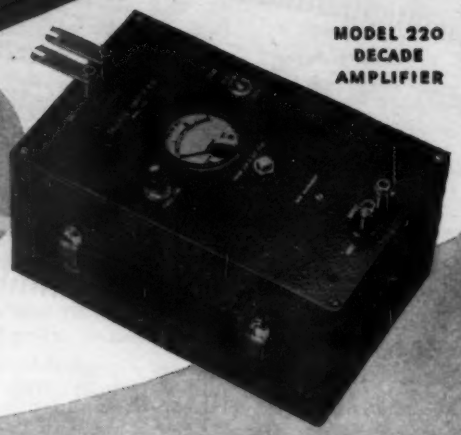

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ticles, helium atoms, traveling at high speeds. It is these alpha particles that produce the ion currents in an ionization chamber. Therefore, a method of counting the number of alpha particles per hour from a sample gives a value proportional to the amount of radon present in the sample. The authors have devised equipment by means of which this may be done and the number per hour printed automatically on adding-machine paper.

First, all oxygen is removed from the sample, since this gas hinders the production of a sharp electrical pulse in the ion counting chamber. The gas sample, minus oxygen, is introduced into the chamber, which is a large can with an insulated rod projecting into the center. The can is connected to a source of voltage of about 1,000 volts.

Under the conditions just described, each alpha particle results in a sharp voltage pulse on the central rod as the ions it produces in shooting through the gas are driven to the central rod by the voltage applied to the can. This occurs in an extremely short time, less than 0.001 second. This sharp pulse is amplified by a vacuum-tube circuit until the current is strong enough to operate a traffic recorder, such as is used to count vehicles on a highway. This device automatically prints the day of the week, the hour of the day, and the number of alpha particles that have passed through the chamber at that hour. This provides the necessary data for computing the amount of radon present.

Operation

A diagram of the complete system for counting alpha particles from radon is shown in the illustration. In use, system is evacuated as far as stopcock T_1 with all other stopcocks in the position shown. With reduced copper in tube C, heated to a dull red, T_7 is closed and T_3 turned to admit a moderate stream of nitrogen from the cylinder through the furnace and drying bulbs into the ion chamber. When the open manometer M shows that atmospheric pressure has been established in the ion chamber, T_6 is closed. The

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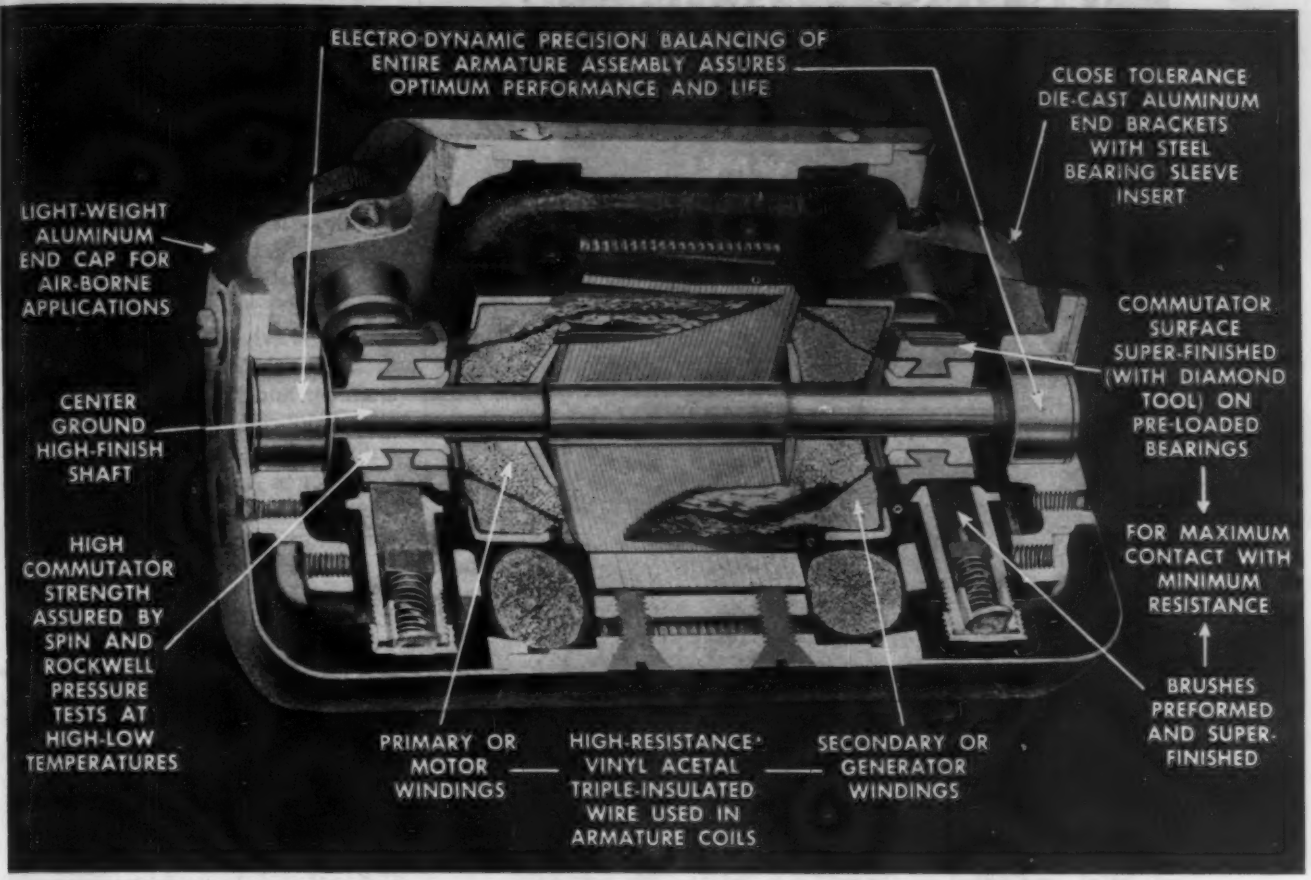
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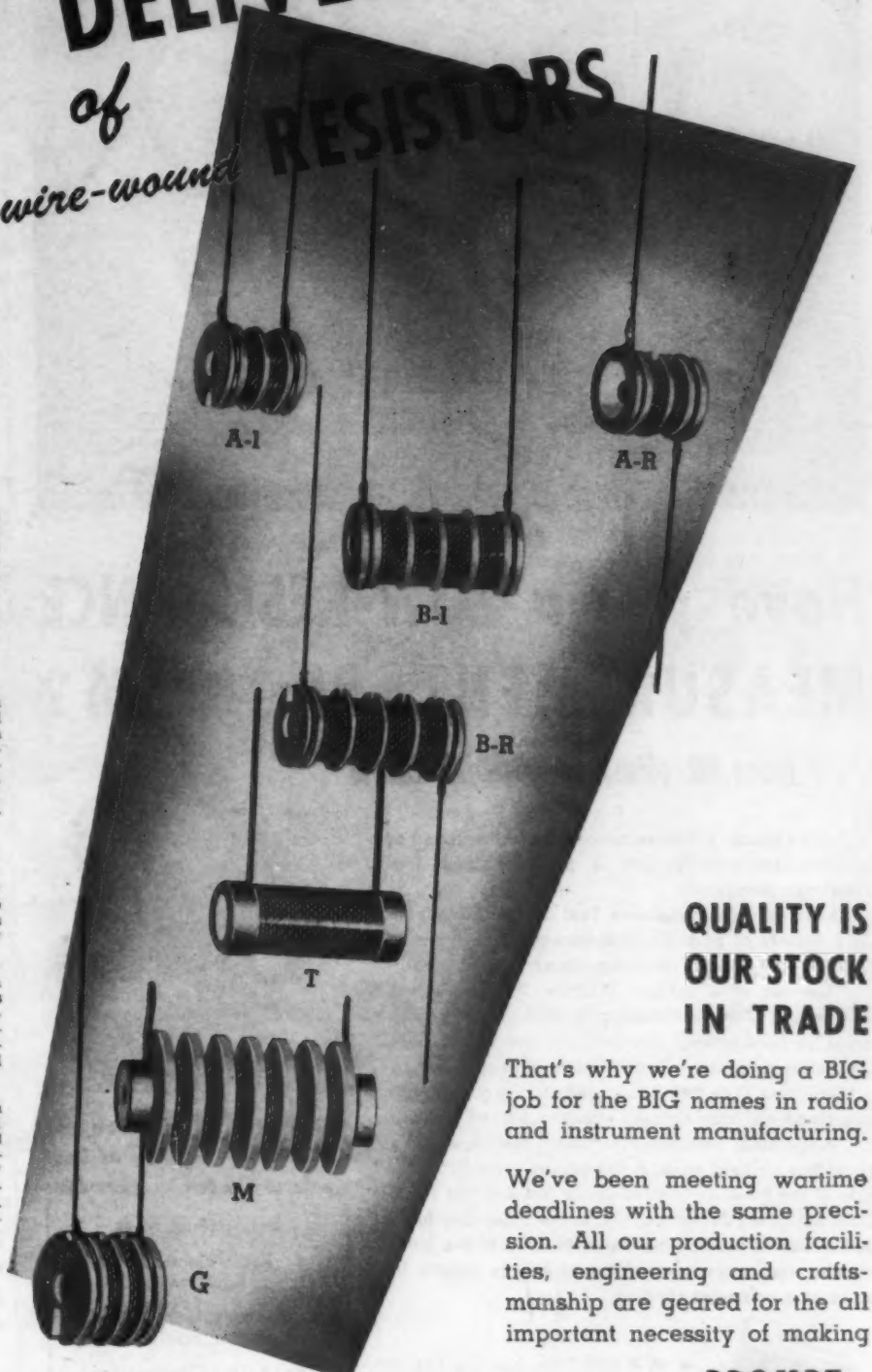

SPECIFICATIONS:

"A-1"—15/32 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 300,000 ohm value—½% standard accuracy—non inductive pie wound—½ watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—200 D. C. maximum operating voltage. Baked varnish finish.

"A-R"—Same as A-1, with leads reversed.

"B-1"—15/16 long x ½" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—½% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"B-R"—Same as B-1, with leads reversed.

"T"—1-1/32 long x 7/16" dia.—Inductively wound—⅛ x .015 strap terminals—35 to 35,000 ohms—2 watts, 100° C. maximum operating temperature—normal accuracy 1%. Baked varnish finish.

"M"—1-13/32 long x ¾" dia.—Mountable with 6-32 screw—⅛ x .015 thick strap terminals—non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C. maximum operating temperature—1.5 watts—1% normal accuracy. Baked varnish finish.

"G"—15/32 long x ½" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value. ½% standard accuracy—non inductive pie wound .8 watts, 30° temperature rise in free air. 100° C. maximum operating temperature. 200 D. C. maximum operating voltage. Baked varnish finish.

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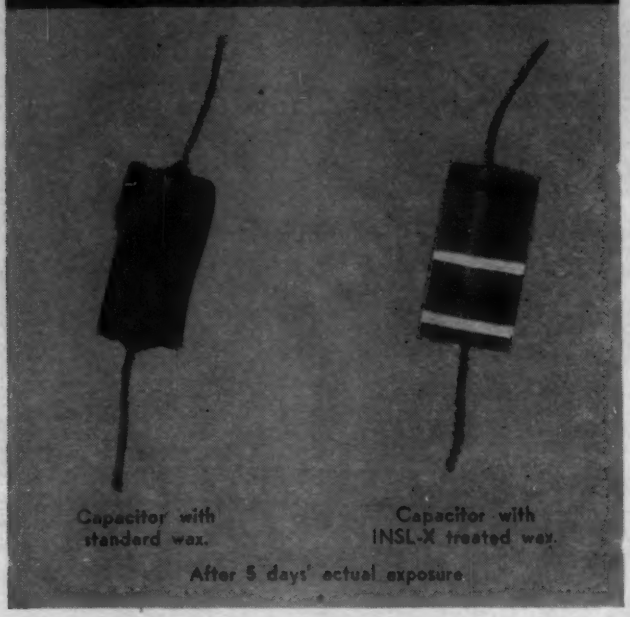

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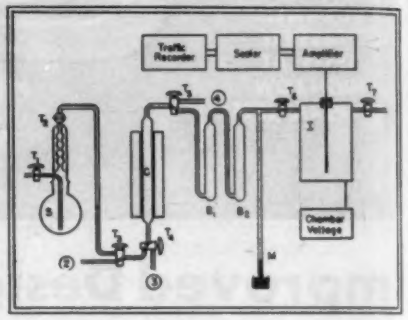
voltage is then applied to the ion chamber and the counting process started.

When a sufficient number of pulses have been recorded for a satisfactory determination of the background, the chamber may be calibrated by admitting a known quantity of radon from the standard radium solution stored in bulb *S*. This is accomplished by again evacuating the system up to stopcock T_3 with the furnace hot. Then nitrogen from the cylinder is admitted slowly through T_1 into the bulb *S* with T_3 and T_4 open to the chamber and T_5 closed. At the same time, sufficient heat is applied to bulb *S* to cause the solution to boil.

Nitrogen is admitted until the pressure in the ion chamber is again atmospheric. This transfers to the ion chamber the quantity of



Complete system for determination of radon. At *I* is the ion-counting chamber; *S* is the standard radium solution; *C*, reduced copper; B_1, Drierite; B_2, P_2O_5; *M*, open mercury manometer.

radon accumulated in the standard solution since it was last removed. This can be computed from the known quantity of radium in the solution and the elapsed time.

The measurement of an unknown may now be made by evacuating the chamber as before and attaching the flask containing the unknown at T_2. Stopcock T_3 is turned to connect the flask to the furnace and a flushing tube is connected to the supply of nitrogen from the cylinder. By closing T_1 and opening T_5, the ion chamber is filled to atmospheric pressure with oxygen-free nitrogen, since the oxygen originally in the sample flask is removed in the furnace. At the same time, the radon in the sample flask is also transferred to the ion chamber. Then T_5 is closed and the

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...This particular (NC-200) set did a darn good job of operation at W3JCE for a year and a half and it worked well in New Zealand on 220 volts 50 cycle with a lamp bank in series; the exact amount of resistance required was estimated by the brilliancy of the pilot light.

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When I received my orders to come back to this country, it almost broke my heart to part with 'Baby', but I sold it because a good radio means a lot out there.

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alpha particles from the sample may be counted.

The new arrangement is so compact that six ion chambers can be operated in the space required for one ionization chamber with its electrometer and camera. No photographic process is involved and the final record is immediately available, thus saving considerable time. Insulation of moderate quality may be used throughout the new equipment, because it is only important that the current be large enough to insure its being counted.

• • •

Phase-Indicating Null Indicator for Bridges

THE USE OF A-C operated bridges is often severely limited by the fact that the usual methods of detection of balance do not indicate the direction of deviation. Thus, in the simplest case of a four-arm bridge with resistive elements, a balance detector sensitive to alternating current will not indicate whether the balancing resistor should be made larger or smaller to reach balance. This makes it practically impossible to use an a-c operated bridge for automatic control purposes because a signal originating in the balance indicator would not indicate, to whatever correcting element is being used, the direction it will have to move in order to obtain balance.

There are several schemes available which will obtain, on a zero-center d-c instrument, deflections to the right or to the left if the deviation of an a-c operated bridge from balance is in opposite directions. An analysis follows of the action of one of the balanced detector circuits for a-c bridges which has recently been used very successfully on the commercial strain gage indicator described in the December 1943 issue of ELECTRONICS.

Consider the simple Wheatstone bridge arrangement shown in Fig. 1. With the bridge in balance, there will be zero voltage between points A and B. When unbalanced with X larger than R_s, point A will be positive with respect to point B on the half cycle during which C is positive with respect to D. That is, the alternating voltage E_{AB} will be in phase with the a-c voltage E_{CD}. With X smaller than demanded by

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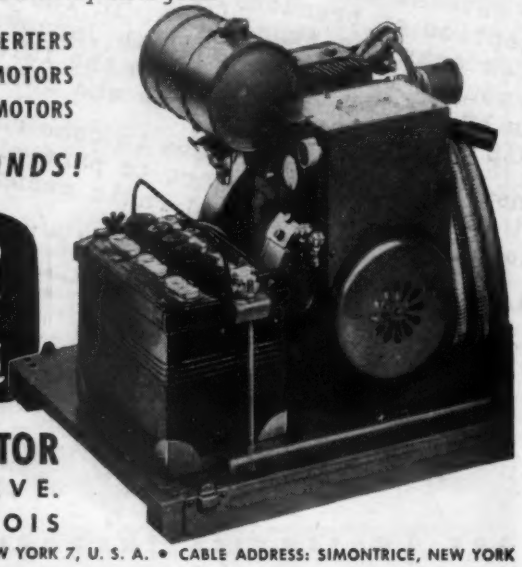

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balance, A will be negative with respect to B during the half cycle that C is positive with respect to D, and the voltage E_{AB} will consequently be 180 deg out of phase with the voltage E_{CD}. It is evident that a balance detector for the voltage E_{AB}, which at the same time would indicate its phase relation with respect to the voltage E_{CD}, would be a valuable addition to the tools of the electrical engineer.

Indicator Circuit

The strain gage indicator referred to uses an unusual arrangement of small dry-type rectifiers as shown in Fig. 2. A 1000-cycle alternating voltage is applied to the bridge and the unbalanced voltage existing between points A and B is fed through an amplifier. The amplified output voltage is applied through a transformer to one diagonal of a four-element rectifier bridge arranged so as to short-circuit itself. The other diagonal is connected to a winding on the transformer furnishing the voltage for the bridge. This voltage is consequently in phase with the voltage

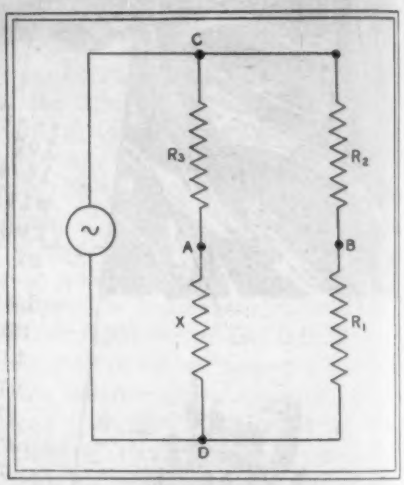

Fig. 1—Wheatstone bridge circuit in which the polarity of the voltage between points A and B changes when the value of X is above and below the value required for balance

E_{CD}. The d-c indicating instrument is connected as shown between the centertaps of the transformer windings connected to the diagonals of the bridge.

To analyze the performance of the circuit, the essential voltage sources and rectifiers are redrawn in fig. 3 where vacuum-tube rectifiers are shown, simply for the con-

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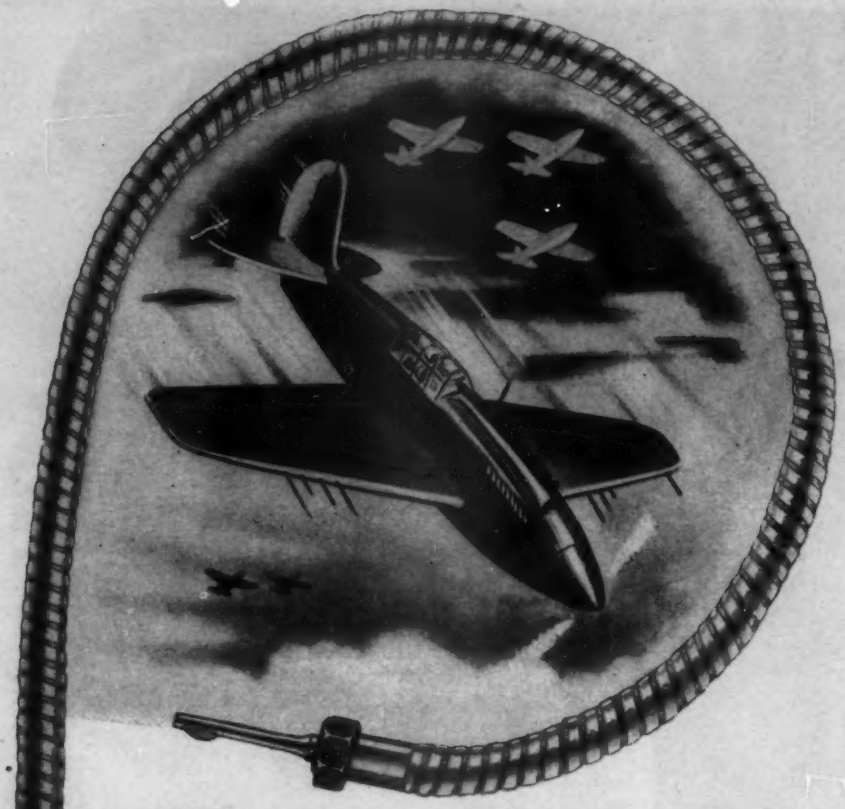

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venience of being able to refer to their terminals as cathode and anode. Resistances are shown in series with the tubes, to illustrate the fact that copper-oxide rectifier elements have appreciable resistance in the forward direction.

One of the voltages can be considered as a reference voltage; this would be the voltage existing between *H* and *F*. Assume this to be an alternating voltage of constant value and considerably larger than the voltage *RT* which we wish to indicate. It will also be convenient to assume the two voltages *HF* and *RT* as square waves.

When the voltage *RT* is zero, voltage *HF* will produce currents alternately through rectifiers *a* and *b*, when *H* is positive with respect to *F*, and through rectifiers *c* and *d*, when *F* is positive with respect to *H*. Assuming equal rectifier characteristics and series resistances, winding *HF* then forms a balanced

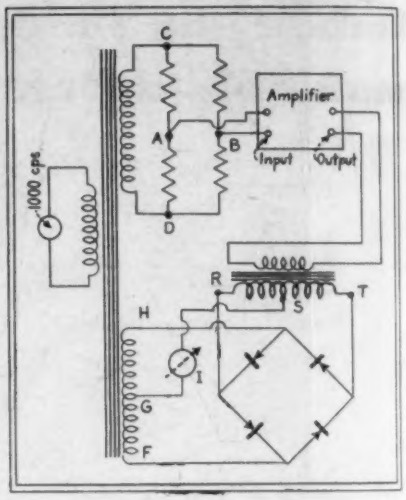

Fig. 2—Circuit of a strain gage indicator containing dry-type rectifiers and an electronic amplifier

bridge circuit alternately with branch *a-b*, and then with branch *c-d*. When no voltage exists across winding *RT*, points *R*, *S* and *T* are always at equal potential, and consequently no current will flow in the meter *I*.

Inoperative Branch

To consider what happens in that branch of rectifiers which is not carrying current at a particular instant, let *R* be just midway between *H* and *F* in potential. Since *G* is also midway between *H* and *F*, no potential exists between *R* and

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G. In either of the two rectifiers *c* and *d*, no current can flow as long as point *T* does not become positive with respect to *H*, in which case rectifier *d* would begin to conduct since its anode would then be positive with respect to the cathode, or as long as point *T* does not become negative with respect to *F*, in which case rectifier *c* would become conducting. Therefore, during the half cycle when *H* is positive with respect to *F*, branch *c-d* could be considered as absent, as long as there are no voltages trying to make point *T* positive with respect to *H* or negative with respect to *F*. During the half cycle when *F* is positive with respect to *H*, similar reasoning applies to branch *a-b* and point *R*.

When *H* is positive with respect to *F*, point *R* is midway between them in potential and the potential of point *T* is then determined by the voltage appearing at this instant across winding *RT*. If this voltage is less than half of the voltage HF, the conditions for considering branch *c-d* as absent, as outlined above, are fulfilled. Assume that the voltage *TR* is 4 volts with *T* positive, when voltage *HF* is 10 volts with *H* positive. Point *S* may then be 2 volts positive with respect to *R*. If the meter resistance is high compared to the resistances in the rectifier branches, point *S* will be also 2 volts positive with respect to point *G*, and current will flow through the meter in the direction from *S* to *G*.

During the next half cycle, *F* will be positive with respect to *H*. Current will flow through branch *c-d*, establishing point *T* midway in potential between *F* and *H*. Branch *a-b* can now be considered as absent. If the voltage *RT* is in phase with voltage *HF*, its polarity will also be reversed, that is, *R* will now be 4 volts positive with respect to *T*, and *S* will again be 2 volts positive with respect to *G*. Current will again be flowing through the meter from *S* to *G*. It is obvious that current would flow through the d-c meter in the opposite direction if the phase of the voltage *RT* would have been assumed opposite, that is, if *T* were negative with respect to *R* during the half cycle when *H* is positive with respect to *F*.

Suppose the two waves are 90 deg out of phase, considering them still

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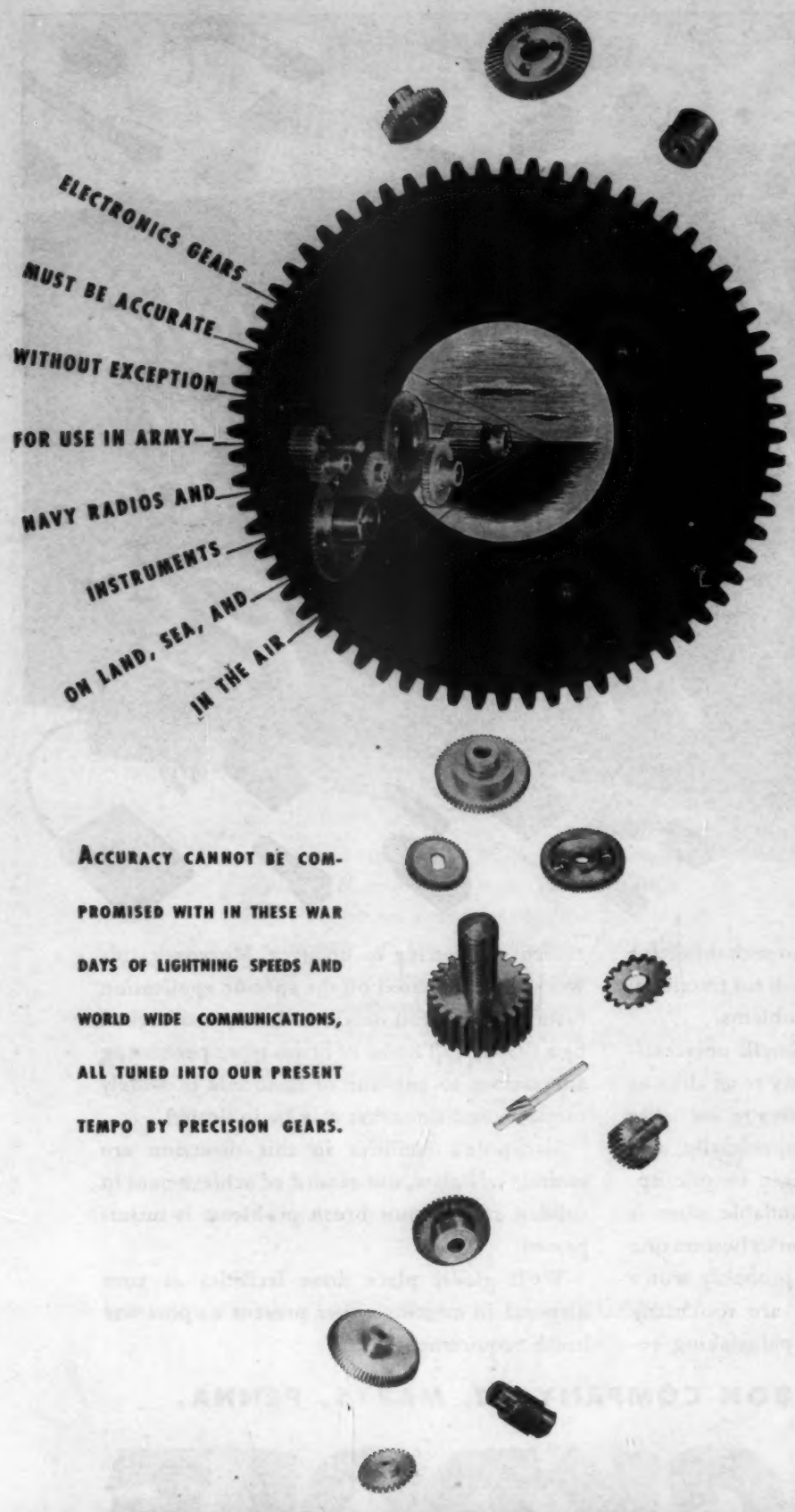

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as square waves. During the half cycle when *H* is positive with respect to *F*, the voltage *RT* changes its polarity, resulting in two equal but opposite impulses of current through the meter, which would therefore read zero. If the phase displacement is less than 90 deg, the impulse in the one direction will be longer than in the other, and the meter will indicate.

Voltage *HF* has been called the reference voltage; it might also be called the "exciting" voltage of the measuring circuit. It does not contribute anything to the reading of the meter, as long as it is at least

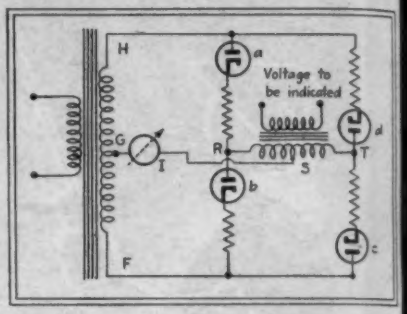

FIG. 3—This simplified circuit of the units shown in Fig. 2 has been drawn with vacuum tube symbols replacing the dry rectifiers for convenience in terminology

twice as much as the voltage *RT*, which is to be measured, or detected. In practical applications it should not be difficult to bring about this condition, so that the meter reading will then be proportional to the voltage *RT* to be measured.

Sinusoidal Waves

If a sinusoidal wave shape is assumed, no change in operation results as long as voltage *RT* is either in phase, or 180 deg out of phase with the reference voltage, and is less than half of the reference voltage. The meter reading will then be determined by the average value of the voltage *RT*.

If a phase displacement between two sinusoidal voltages exists, there will be periods when the instantaneous value of the voltage *RT* will be higher than half of the voltage *HF* (most obviously near the time and at the instant when voltage *HF* passes through zero). During this period, the original basis that branches *a-b* and *c-d* can be considered alternately as absent is not

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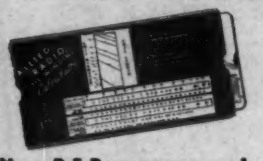

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true any more. In the original analysis, rectifiers *d* and *c* were entirely inoperative during the half cycle when *H* was positive, provided the voltage *RT* was less than half of the voltage *HF*. If this is not the case, current will flow in one of the two rectifier elements, in *d* for example when *T* is more positive with respect to *R* than *H* is positive with respect to *G*, or in other words, if the voltage *RT* is more than half of the voltage *HF*. Regardless of this additional current in element *d*, *S* will still be positive with respect to *G*, and current will flow in the meter *I* the same as under our original assumption. Only the proportionality factor between the indication of the meter and the voltage *RT* will change the moment that rectifier *d* becomes active. Qualitatively nothing will change when our original assumption (voltage *RT* less than half of voltage *HF*) is not fulfilled any more. With exactly 90 deg phase displacement between the two voltages, the meter will read zero; with a phase displacement less or more than 90 deg, the current through the meter will be in one or the other direction.

Application

In control circuits, the meter may be replaced by a polarized d-c relay. As possible applications, phase reversal relays, control operation

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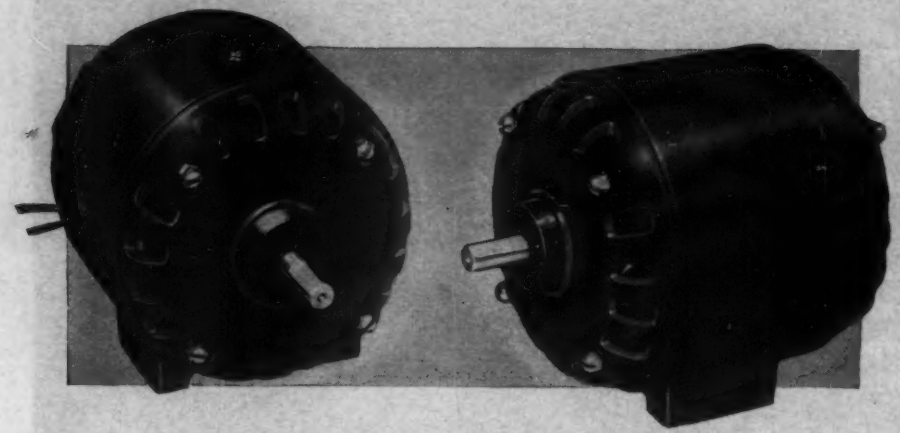

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from a-c operated bridges (resistance thermometers, for instance) come to mind. Another highly valuable feature of this circuit is that a voltage differing in frequency from the reference voltage will not cause any reading on the meter. This means that a 60-cycle magnetic pick-up in the leads will not cause any deflection in the meter, as it would if the balance indicator would simply indicate the presence of any alternating voltage. This frequency discriminating action of the circuit may provide other extremely interesting possibilities. If the reference voltage has, for example, a frequency of 300 cps, a meter reading will be obtained only if the voltage *RT* is also of 300 cycles, or has a component of this frequency, and if this 300-cycle component has in turn a component in phase (or 180 deg out of phase) with the 300-cycle reference voltage.

If the reference voltage is 60 cycles while voltage *RT* is 59 cycles, these two voltages beat together to produce a frequency of one cps. The d-c meter will then swing from a positive to a negative indication and back once every second; a maximum positive indication would for instance be a sign that the two voltages are in phase, and a polarized relay in place of the meter might be used for automatic synchronization of a-c generators.

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Communication for Trains

(*Continued from page* 107)

breakage, the communications system may be rendered inoperative.

From a service point of view, rail carrier systems, which normally operate at low carrier frequencies, utilize portions of the frequency spectrum where many carrier circuits of telephone, telegraph and electric power companies now operate. This means that the number of available communicating channels is relatively small, possibly limiting the use of rail carrier systems to operational communications only, without provision for various passenger services.

Induction Radio Systems

Induction radio systems combine many of the features employed in space radio and rail carrier telephone systems. Although induction radio systems of the type under discussion operate at radio frequencies, use is made of the combined r-f induction and radiation fields existing in close proximity to loop radiators and wayside wires on which radio-frequency signal energy is impressed.[2, 4, 5]

Induction radio systems are distinguished from normal space radio systems for the reason that in induction radio techniques use is made of the localized and highly-concentrated r-f induction and radiation fields which exist in close proximity to loop and other radiators. These fields are usually considered to be within the distance of $157{,}000/f$ feet where f is in kc, while space radio systems utilize the radiation field existant in space at distances considerably beyond those at which the induction field is effective.

Induction radio techniques differ from those employed in rail carrier telephone communication systems, in that signal energy at radio frequencies is impressed primarily on wayside wires rather than on rail circuits, while the combined induction and radiation field surrounding these wires is utilized for communication purposes. No conductive connections are required to rail or wire circuits.

Inasmuch as induction radio signaling methods do not employ low-

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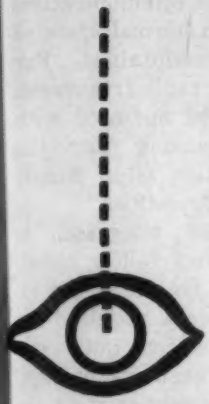

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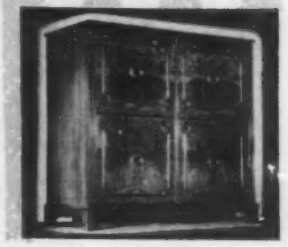

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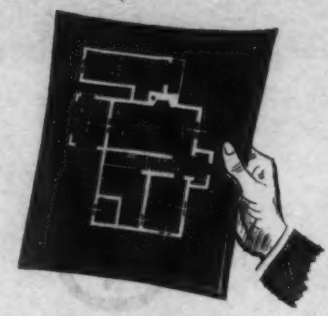

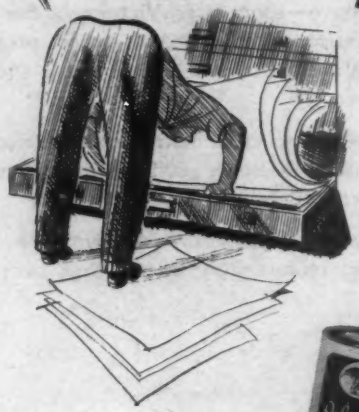

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impedance rail circuits which rapidly attenuate signal energy at frequencies above 10 kc, relatively low-power equipment, comparable in power output rating, size, weight and cost to space radio equipment, can be utilized for two-way communication between mobile units and wayside stations over distances of 100 miles where normally-existent wayside lines are present.

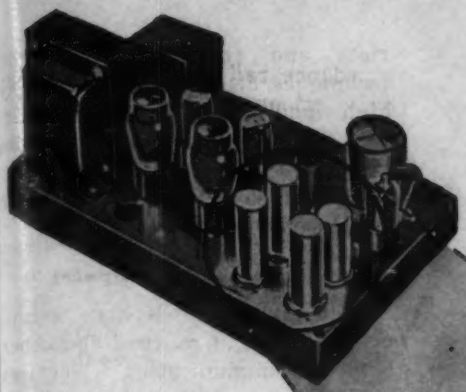
Induction radio systems also have a desirable characteristic possessed by rail carrier telephone systems with respect to restriction in lateral extent of the signal zone, so that relative privacy of communications, as compared with normal space radio systems, is maintained. Further, at the lower radio frequencies, equipment may be operated without Federal licensing providing that such operation is in compliance with FCC regulations.

Since telephone, telegraph, or electric power lines follow closely most all railroad trackage, the extensive wire network required for operation of induction radio systems on a comprehensive national basis is already largely existent. In the limited number of instances where wires leave the vicinity of the railroad right of way for distances greater than several hundred feet, inexpensive installations of one or two wires across the gap will carry the r-f carrier signals to the points where the normal wire circuits again are in proximity to the tracks.

Induction radio techniques appear to be well-adapted for use in various urban and mountainous areas through which railroads operate. Signals impressed on wayside wires will follow the curvature of trackage in sections where space-radiated signals cannot readily be received without the aid of repeating equipment.

As induction radio techniques are not dependent on rail circuits, damage to the tracks does not prevent effective functioning of the system. Communications may usually be maintained in event of line breaks even though at reduced efficiency (as is commonly the case in carrier telephone installations of electric power companies), because adjacent lines or tracks themselves will often provide an inductive bridge across a break in a line.

The use of radio-frequency car-



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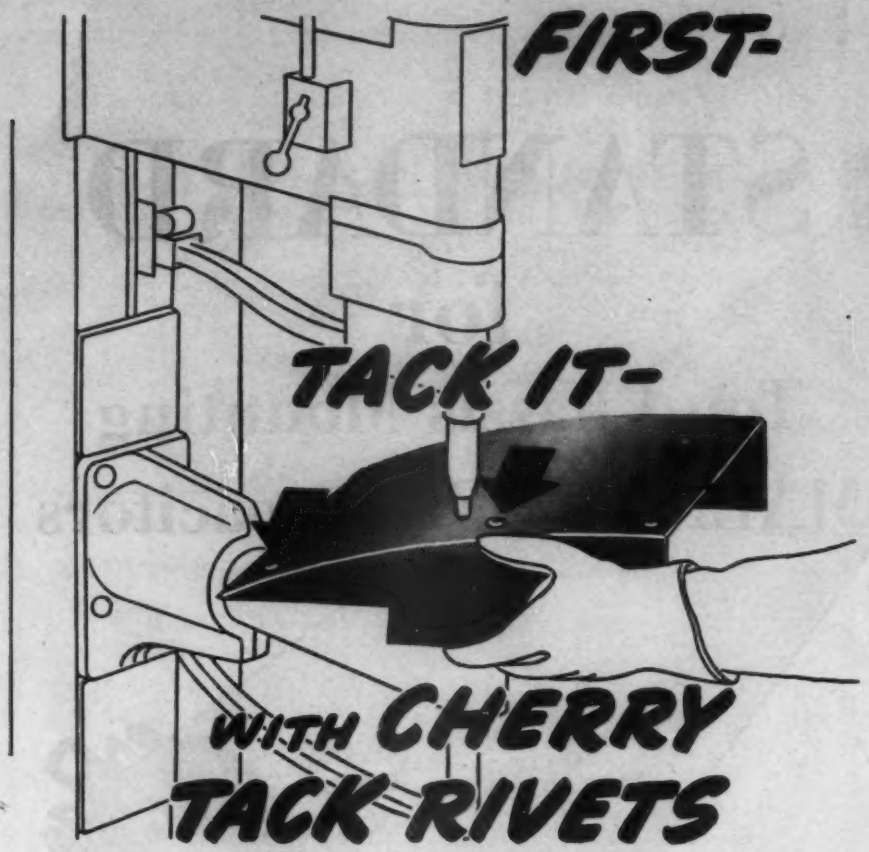

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riers and frequency-modulation techniques also provides relatively high signal-to-noise ratios at receiving stations where electric noise levels are of considerable magnitude, as in electric or Diesel-electric locomotives.

Induction Radio Equipment

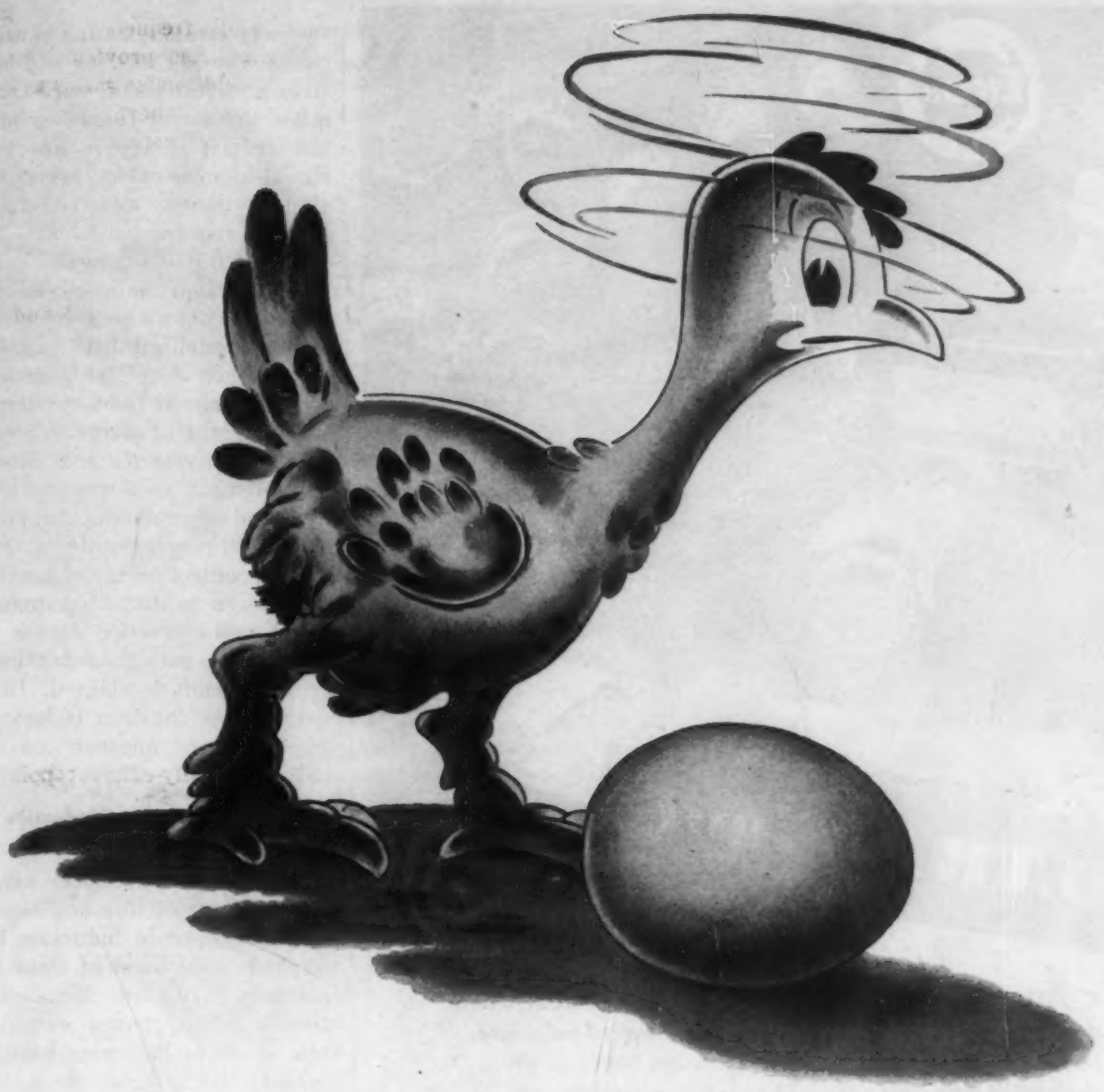
Induction radiotelephone equipment utilized in railroad and other traffic communicating services usually employs central station or wayside transmitters with power output ratings ranging from 3 to 25 watts. Frequencies used are normally in the portion of the radio-frequency spectrum extending from 50 to 200 kc, although lower or higher frequencies may be utilized.

Signal energy may be impressed on wayside wire circuits through inductive coupling between the wire circuits and an r-f transmission line extending parallel to and in close proximity to such wires, or by means of capacitive coupling between the output circuit of the transmitter and the one or more existing wayside wires which extend along traffic lanes. In the former case, the transmission line or induction cable is usually located parallel to and several feet from existing wayside wires. The line is terminated in its characteristic impedance to reduce standing waves and resultant excessive radiation from the line.

In induction radiotelephone systems developed by the Halstead Corporation an r-f attenuator unit, usually adjustable in 2-db steps, is sometimes employed in the power output circuit of the transmitter to facilitate regulation of the amount of r-f power impressed on wire circuits without requiring a change in the output loading circuit of the transmitter. This unit also aids non-technical personnel in maintaining optimum field intensity under varying weather conditions, when moisture on line insulators may cause greater attenuation of r-f signal energy than when insulators are dry.

Receiving equipment may be coupled to the r-f transmission line or to one or more wayside wires through suitable capacitors, as shown in Fig. 5.

Although amplitude-modulated induction radiotelephone equipment has been successfully employed in



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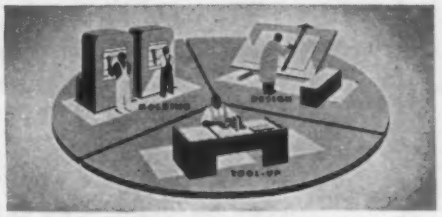

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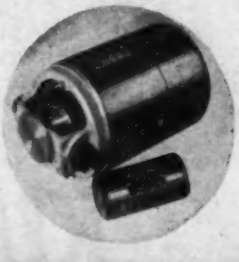

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two-way communication service between wayside stations and locomotives at distances of more than 100 miles, the use of frequency modulation results in appreciably greater signal-to-noise ratios, better overall signal quality, and reduction in power requirements of mobile transmitting equipment. Tests of f-m induction radiotelephone systems have shown that voice signals of good intelligibility may be received when electrical noise level is of such magnitude as to completely over-ride amplitude-modulated signals of equivalent signal intensity.

Equipment employed on locomotives and other mobile units usually incorporates transmitters, receivers and control units similar in general design to that used in conventional radio practice at the lower frequencies, with the exception that a loop antenna is utilized. In some installations the loop is located on the tender or another convenient and electrically-efficient point.

Arrangement of Induction Equipment

The general electrical arrangement of transmitting and receiving units employed in induction radiotelephone equipment of mobile type is shown in Fig. 6. Mobile transmitters having power output ratings of 10 to 25 watts have been successfully utilized, with power rating usually being dependent upon the size and overall electrical efficiency of the loop radiator.

Receiving equipment normally employs an electronic squelch circuit to effect silencing of the audio-output system except during periods in which an effective carrier signal is being received. A carrier-operated relay is incorporated in the squelch circuit of the receiver to operate a check-light, as in some space radio systems designed for railway service.

Operation of locomotive equipment is such that an intense r-f field is developed in proximity to wayside conductors by the combined induction and radiation fields existent in the vicinity of a loop antenna. The signal energy induced on wayside wires is then utilized for communications purposes, attenuation per unit length of line being sufficiently low to permit maintenance of satisfactory signal-to-noise ratios at receiving loca-

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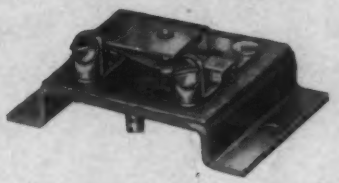

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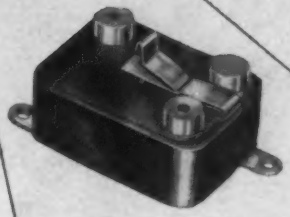
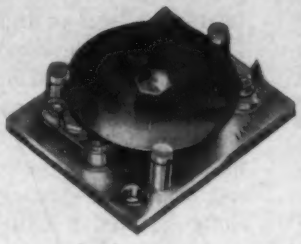
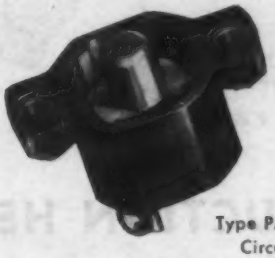


Type C-7220 Precision Snap Switch. 12 amps. 30 Volts D.C., 125 Volts A.C.

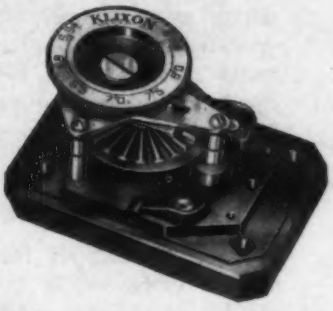


Type B-3120 Thermostat and Heater, Crystal Dew Point Control



Type PM (NAF-1131) Circuit Breaker

Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens



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tions along railroad right of ways.

In order to expand the useful range of induction radiotelephone systems along longitudinally-extending lanes of traffic such as railway tracks and highways, automatic f-m repeater equipment has been developed. A representative repeater unit of this type is illustrated in Fig. 7 and 8. This equipment includes an f-m receiver and associated repeater or zone transmitter. A carrier-operated relay employed in the receiver is utilized in applying transmitter plate power during periods in which carrier signal energy is received from a preceding repeater, central station, or mobile transmitter. The control circuits are such that the transmitter may also be locally controlled to permit its use in such wayside points as signal towers and other selected locations along railroad right of ways.

Repeater Operation

Through the use of automatic repeater systems of this type, signals from a mobile unit or wayside transmitter operating on a given carrier frequency may be received at a repeater station and thence retransmitted automatically at a second carrier frequency to any point along extensive railroad right of ways. In such repeater installations, the audio-visual checking system is of operational value in establishing the integrity of the entire connecting network. A master checking signal is transmitted from the primary control station and is relayed along the repeater network to its termination. Reception of the recurrent checking signal in all locomotives or other mobile units provides aural as well as visual indication of proper operation of the entire system, while the carrier-operated pulse lock-out method prevents interference between the checking signals and voice signals from mobile units or secondary stations.

Operating Cab Signal Lights

An adaptation of the signaling method employed in the checking system provides a practicable and relatively simple means for effecting selective operation of red, green or amber lights within locomotive cabs when supplementary signal in-

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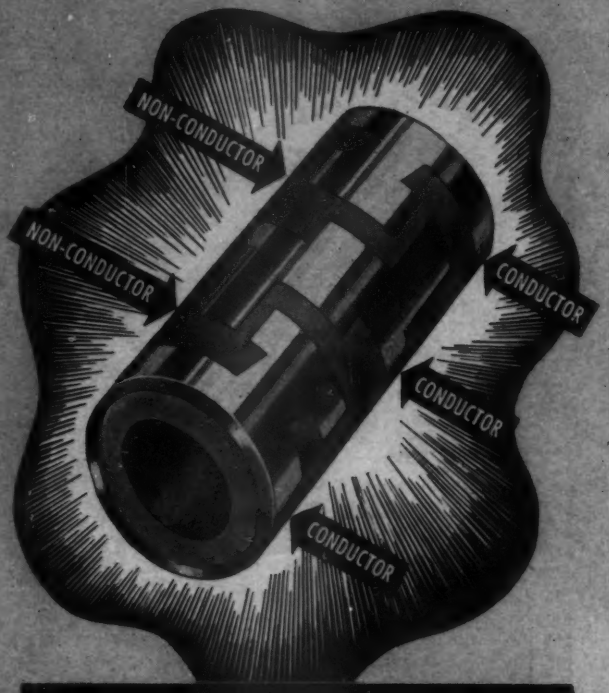

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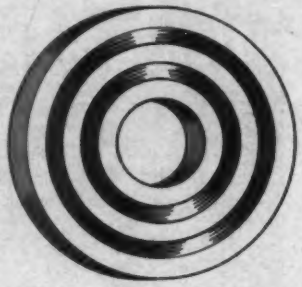

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dications of this type are desired. Audio-frequency band-pass filters, signal rectifiers and relays are connected with the locomotive receiver to effect selective control of the signal lights, as shown in Fig. 9, with relay interconnections being such that failure of carrier signaling circuits will cause a red light to be energized.

In this application of radio traffic control techniques, tone signals of definite audio frequency, correlated with and indicative of such traffic control signals as "stop", "proceed", and "caution", are transmitted to the locomotive cab by a low-power wayside transmitter with an associated r-f transmission line disposed in proximity to the track for the length of a desired signaling zone. The control signals are also reproduced by the cab loudspeaker, thereby serving as an aural aid and supplementary check on the visual control indication. Units of this type may prove to be of particular value on trackage leading to the "hump" of classification yards, where substantially continuous control indications are desirable.

Disadvantages of Induction Radio

While induction radio systems will undoubtedly be utilized in many important railway services, there are several important factors to be considered in determining to what extent this type of signaling should be employed.

At points on main line trackage where wayside wires may be buried, installed in lead-sheathing, or where wires run at substantial distances from trackage, as in freight yards, supplementary wires must be installed. While this may be a relatively inexpensive matter in most instances, it does involve some complications.

In the event of floods or severe storms, during which wire lines may be destroyed or damaged for considerable distances, the system is likely to be made inoperative within the damaged area.

As in rail and other carrier telephone services, the number of available communications channels is not great. However, as the effective signaling zone extends only for a limited distance from track areas, this problem may not be of sufficient magnitude to prevent extensive use of induction radio tech-

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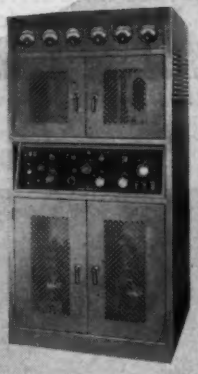

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niques, especially along main line trackage.

Conclusions

Although no one at the present time can predict with any degree of certainty the extent to which any of the systems described above will be applied to railroad operation, it is believed that comprehensive tests now being conducted will indicate to what extent each of the three systems can best serve the railroad industry.

It is probable, therefore, that within the coming year there will be sufficient technical data and operational experience to guide railroad operators in properly evaluating the respective merits of the various systems. Test installations should likewise provide railroad operators with tangible evidence of the extent to which the various train communications techniques can increase the efficiency and safety of rail operations.

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(2) Grondahl, L. O., and Bossard, P. N. Train Communications, *Electrical Engineering*, p. 493-500, July 1943.
(3) Halstead, W. S., Induction Radio, *Electronic Industries*, p. 86-89, Dec. 1943.
(4) Tune 550—Highway Radio Ahead, ELECTRONICS, p. 32, Sept. 1940.
(5) *Proc. I.R.E.*, 29, p. 95, March 1941.

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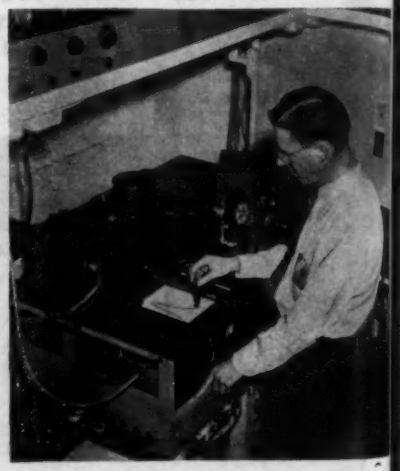
ELECTRONIC COLOR RECORDER



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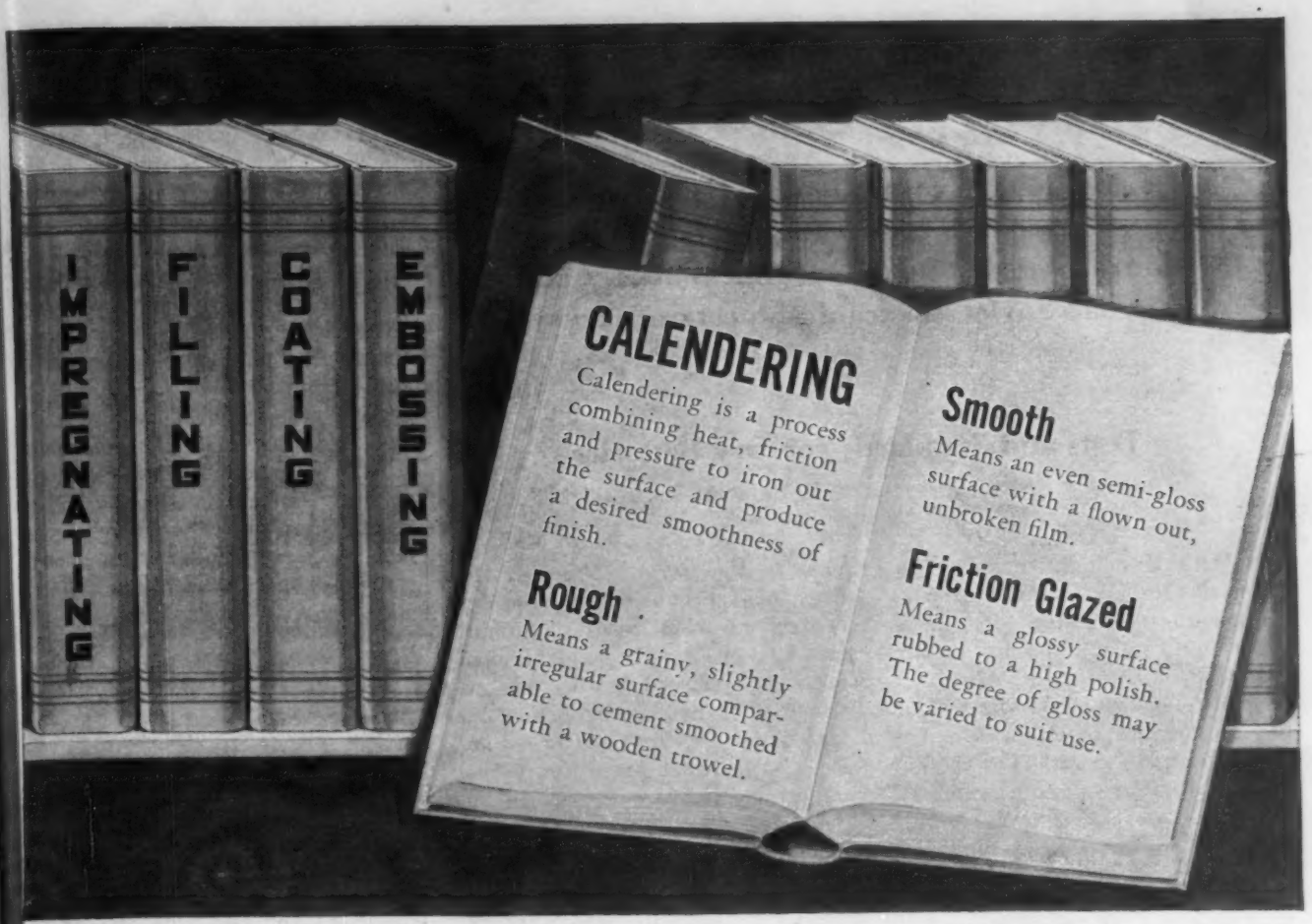
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Tests and Standards for Dry Batteries

By Dr. Charles E. Skinner
Senior Electrical Engineer
Fort Monmouth Signal Laboratory

In the early 20's, the Signal Corps of the U.S. Army entered into a program of testing for its increasing use of batteries in communication equipment. Specifications, following closely the lead of those adopted by other organizations, were formulated for the purchase of batteries and a systematic program of testing in accordance with the specification was initiated. This program of testing revealed many conditions in which battery improvement seemed possible and studies were undertaken in the Signal Corps Laboratories and in cooperation with battery manufacturers to secure these improvements. These improvements were incorporated in revised specifications from time to time and provision made for rewarding manufacturers producing the most satisfactory batteries.

Development of standard test methods and equipment has received much attention in the Battery Branch at the Fort Monmouth Signal Laboratory. Every effort has been made to design and build such test equipment so errors in making tests are kept to the practicable minimum. Some of this testing equipment is illustrated. Provision is made for qualification, preproduction, and contractual tests in very considerable volumes. These provisions also include equipment for controlled storage temperatures as required by specifications. In addition, a large volume of development and research testing is provided for, together with elaborate equipment for simulating the climatic conditions which may be met with in any part of the world. Much of this equipment provides for automatic control of temperatures, humidities, and cycling times. This elaborate and careful testing has resulted in many and important improvements in dry batteries and has also provided leads for further important improvements such as increased shelf life, better performance in tropical and arctic areas, and better matching of battery characteristics to equipment requirements.

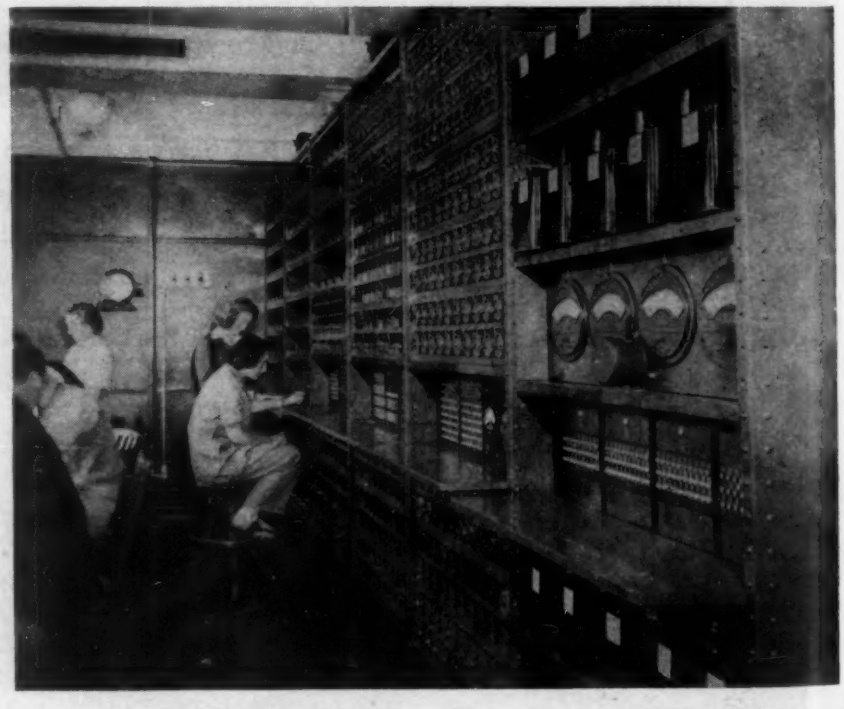
Military Types

At the present time the Signal Corps has accepted 17 recognized standard cells varying in size and weight from the K (17/32 in. in diameter by ½ in. in height, weighing 0.009 lb.) to the number 6 (2½ in. in diameter by 6 in. in height, weighing 2.2 lbs.). Capacity of cells is approximately in proportion to their sizes. Standard battery voltages vary from 1.5 in single cell batteries to 150 or more in series-connected combinations. Increased current output is obtained by connecting cells in parallel. Multi-cell batteries may comprise various sizes of cells connected for various voltages and currents.

The number of battery types recognized as standard has grown rapidly in recent years. The following table shows the growth:

Year	Types
1924	7
1930	10
1932	12
1938	15
1940	14
1942	37
1944	50

The Signal Corps Standards Agency (SCSA) has prepared tables listing these standard batteries as used with Signal Corps equipment and also a list of equipment to which each standard battery is applied. Another table has been prepared by the Battery Branch giving essential data for each standard cell, such as overall



Test equipment used by the Signal Corps General Development Laboratories, Fort Monmouth, N. J., includes this bay of panels for checking several specific types. Atmosphere is controlled to 70 deg F and relative humidity of 50-70 percent

Establishes Frequencies at UHF with QUARTZ CRYSTAL Accuracy

- Designed especially for calibrating with crystal accuracy up to and beyond 2000 megacycles.
- Provides more usable output at higher frequencies.
- Affords FAST, EASY calibration.
- Especially suited for wavemeters, signal generators, oscillators, receivers, etc.
- Transmission line output. Detector unit built into calibrator.

Write for detailed information.

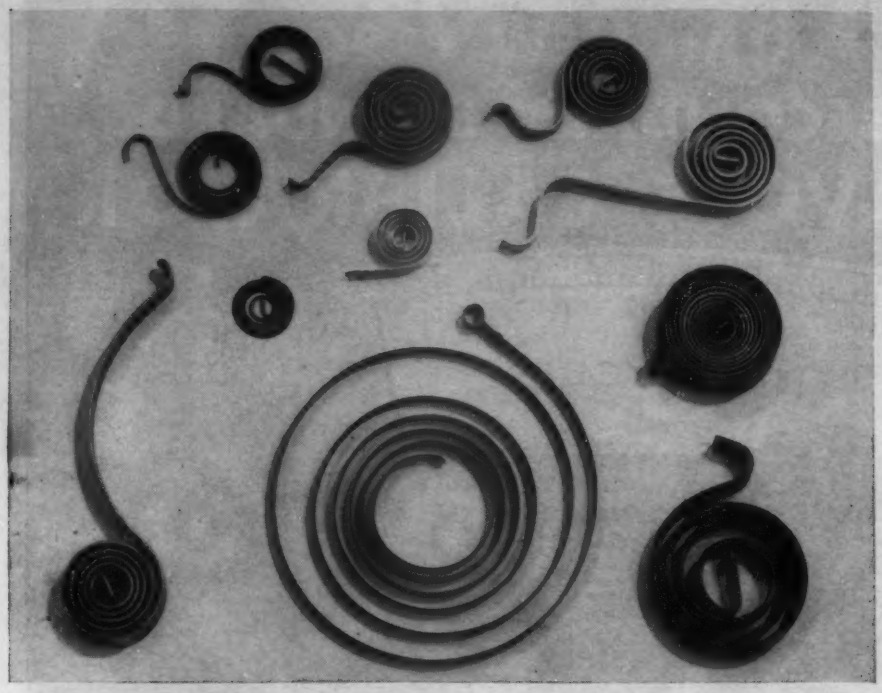
U H F

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS

MORGANVILLE, N. J.

Specialists in the Development of UHF Equipment



springs for ELECTRONIC USES

The electronics-radio industry makes severe demands on the talents of any spring producer. Reliable has abundant experience in supplying all types of springs of extreme precision for builders of aircraft and aircraft equipment, and also for various electrical devices. Reliable is well equipped to furnish springs to exact engineering specifications, for communication, broadcasting, and receiving apparatus, as well as control and ranging equipment, and for all industrial applications of electronic devices. The physical and electrical requirements of our products are held within narrow limits.

We believe that Reliable's superior standards of craftsmanship are extremely important to those who use springs in electrically operated equipment—and that by the use of our springs you assure, in your products, better service and performance.

Consult with us on your requirements. Reliable Catalog No. 44 supplied on request.

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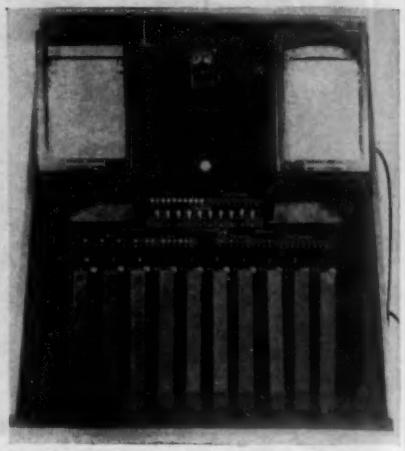
dimensions, initial drain, discharge schedule, initial service life, and service life after storage.

It is obvious that since multiple cell batteries are combinations of different sizes, numbers, and arrangements of cells, an almost unlimited variety of batteries is possible. It is also obvious that every battery added to the already considerable list of standards increases the difficulty of procurement, stock keeping, assignment to equipment, shipment, storage, and distribution at places of use. This, combined with the fact that all dry batteries have a limited shelf life, depending to some extent on the



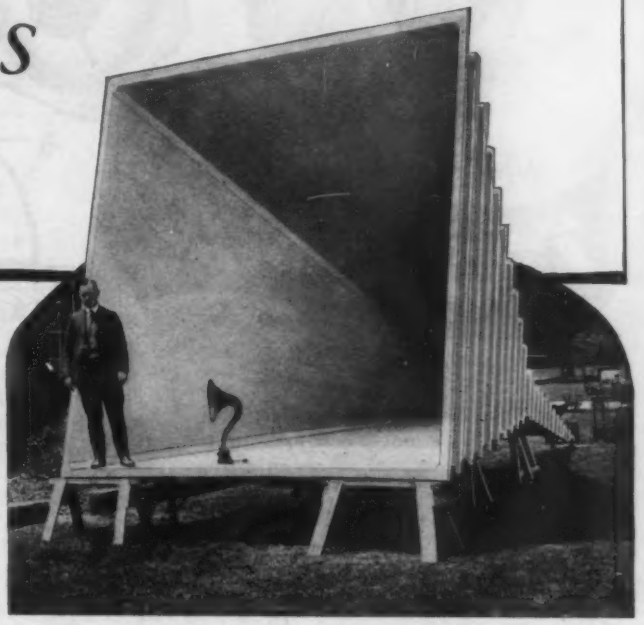
Automatic battery test set provides choices between continuous and program loads with panel-light indication and moving-chart records of results

conditions of storage, makes it extremely desirable that the standard list be kept to the absolute minimum consistent with the fulfillment of all necessary requirements. To this end it has been arranged that no additions can be made to the standard list until necessity has been proved and proper authority secured.

The latest specification in use, Signal Corps Tentative Specification 70-21-P—Bureau of Ships Ad Interim Spec. 17-B-7 (Int.), was formulated by representatives of the Army, Navy, and industries under the direction of the SCSA. This specification provides standards for both the Army and the Navy and facilitates procurement of batteries for all services by one agency. This original specification is to become a joint Army-Navy specification to be know as JAN-B-18.

Recent studies have resulted in

MAGNAVOX *HAS MADE ELECTRONIC HISTORY FOR 30 YEARS*



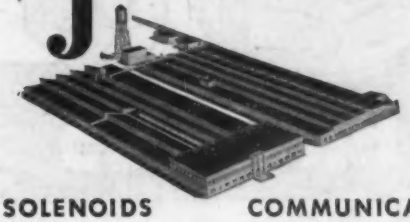
Largest loud speaker ever built—heard 9 miles. Built for Idora Amusement Park, Oakland, Cal., in 1922. Standing in the speaker is E. S. Pridham, now a vice-president, one of the founders of Magnavox, and co-inventor of the electro-dynamic speaker.

THIS GIANT SPEAKER was a Magnavox development of twenty years ago . . . an early example of the pioneering by which Magnavox has produced so many outstanding contributions to the radio industry. Among those contributions was the electro-dynamic speaker, the "voice" of all modern electronic sound reproduction.

Present wartime experience will enable Magnavox to serve the peacetime needs of the radio industry even better than before. With stepped-up efficiency and the excellent facilities of the modern six-acre plant, Magnavox will again supply components for radio manufacturers, and will figure prominently in the coming peacetime developments of electronics. The Magnavox Company, Fort Wayne 4, Ind.

Magnavox craftsmanship won the first "E" award in this field (1941), now with 3 White Star Renewal Citations.

Magnavox



LOUD SPEAKERS • CAPACITORS • SOLENOIDS **COMMUNICATION & ELECTRONIC EQUIPMENT**

ANNOUNCING BULLETIN NO. 143

Every engineer in the electronic field will appreciate the concise method in which the Electrical and Mechanical properties together with the design and dimensions of AlSiMag High Frequency Insulators have been arranged and tabulated for easy and quick reference in new Bulletin No. 143.

The AlSiMag insulators described are those most commonly used in high frequency applications. *Deliveries can now be made within a reasonable period.*

Note: *When requesting copies please include name and position of others in your organization to whom we should send Bulletin No. 143 so that you may retain your own copy.*

The insulators described in Bulletin No. 143 represent only a small portion of our output. Specially made insulators to customer's specifications are our principal products. Our Engineering Staff will be glad to cooperate on your designs.

AMERICAN LAVA CORPORATION

Chattanooga 5, Tennessee

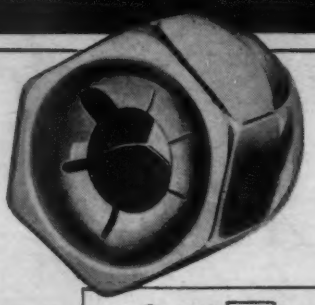
ARMY E NAVY

ALCO has just been awarded for the fourth time the Army-Navy "E" Award for "continued excellence in quantity and quality of essential war production."

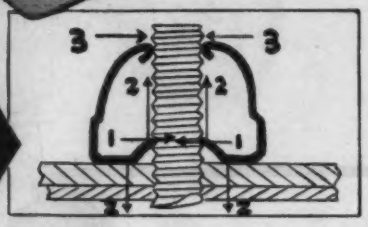
ALSIMAG

CERAMIC INSULATORS

NEW TYPE NO. 6NAO SELF-LOCKING PALNUTS



With the **TRIPLE GRIP**

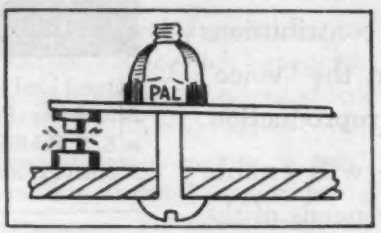


When the Type 6NAO Palnut is tightened, its arched, slotted jaws grip the bolt like a chuck (1-1), while spring tension is exerted upward on the bolt threads and downward on the part (2-2), securely locking both. A third grip is exerted around the top of the bolt by spring tension at 3-3.

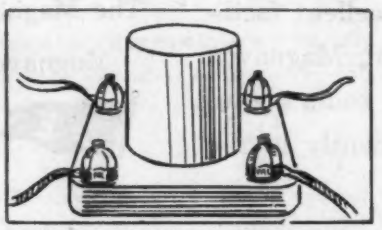
The new Type 6NAO Self-Locking Palnut may be used as a one-piece locknut to securely fasten parts—or as an adjusting nut to maintain accurate settings anywhere on the screw. (See typical uses herewith.)

When used as a fastening, the full triple grip is utilized to keep parts tight under vibration, without need of lockwashers. When used as an adjusting nut, the third gripping action (3-3) locks it firmly in position.

Type 6NAO Palnuts are single thread locknuts, made of tempered spring steel. Light in weight, low in cost, easily, speedily applied. Send details of your assembly for samples and suggestions. Write for new data sheet and copy of Palnut Manual No. 2, giving information on all types of Self-Locking Palnuts.



As adjusting nut on contact switch.



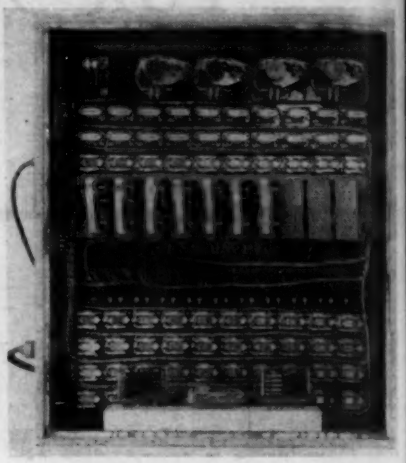
As fastening to hold electrical terminals.

THE PALNUT COMPANY
77 CORDIER ST. IRVINGTON 11, N. J.

Self-Locking PALNUTS

the adoption of standard procedures and materials for moisture-proofing assemblies and jackets of dry batteries to meet the severe climatic conditions prevailing in tropical areas. This treatment, now generally followed by battery manufacturers, consists of impregnating and coating assembly materials and jackets with a suitable moisture resistant wax.

A standard packaging specification has been formulated under direction of the Signal Corps Storage and Issue Agency in Philadelphia and is now generally followed by manufacturers. This specification



Rear view of test set illustrated shows how interchangeable resistor banks plug in on banana-pin base mount

requires that batteries be packaged in vapor proof bags which give protection from moisture and fungus during shipment and in storage. These steps are expected to be effective in protection during shipment, storage, and service regardless of the area in which batteries are to be used.

Practical Benefits

Benefits which accrue from the program of testing, specification writing, and standardization are many, among which are the following:

(a) Procurement of batteries for Signal Corps use is restricted to a reasonable number of standards.

(b) Very large numbers of the major types are ordered and used, permitting continuous-quality manufacture on assembly lines in the most efficient manner possible.

(c) Various services utilize the

Final test—Remler marine amplified sound transmitting equipment.

REMLER IS EQUIPPED with facilities for the mass production of complete announcing and amplified sound transmitting equipment; radio; plugs and connectors. Skilled technicians and vigilant inspectors check and re-check final products to meet rigid specifications. The facilities of this organization backed by twenty-five years of experience in the manufacture of electronic products and plastics, is at your disposal for further assignments.

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REMLER

SINCE 1918

Announcing & Communication Equipment

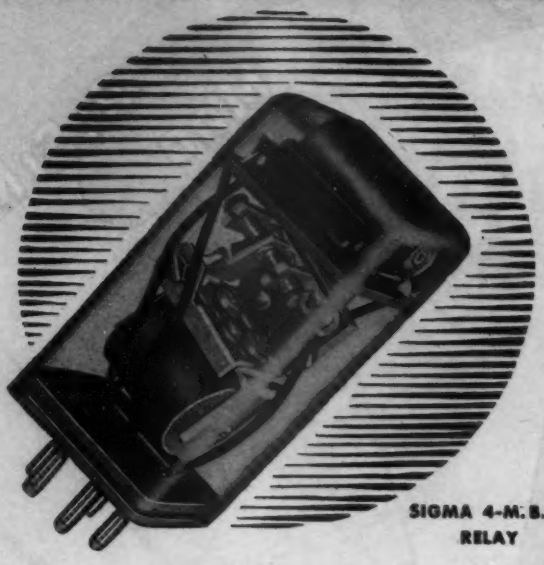
PLUGS & CONNECTORS

Signal Corps · Navy Specifications

Types: PL					NAF
50-A	61	74	114	150	
54	62	76	119	159	
55	63	77	120	160	1136-1
56	64	104	124	291-A	
58	65	108	125	354	No.
59	67	109	127		212938-1
60	68	112	149		

PLP		PLQ		PLS	
56	65	56	65	56	64
59	67	59	67	59	65
60	74	60	74	60	74
61	76	61	76	61	76
62	77	62	77	62	77
63	104	63	104	63	104
64		64			

OTHER DESIGNS TO ORDER



SIGMA 4-M.B.R. RELAY

AC SENSITIVE RELAYS... WITH DC PERFORMANCE

The conventional AC relay of shaded pole construction has two limitations.

(1) Its power sensitivity is only a small fraction of that afforded by the same relay operated on DC.

(2) It cannot be successfully operated on a gradually variable voltage or current without passing through states of instability and chattering. This limits its usefulness to circuits in which the input is sharply changed from one level to another and rules it out for sensitive control on continuously variable AC.

SIGMA has perfected a complete unit which is an adaptation of most SIGMA Sensitive relays to AC operation with neither of the above disadvantages, by incorporating within the relay housing a midget selenium rectifier of the full wave type, with or without a filter condenser as circumstances dictate. Operation is attained on continuously variable AC with no instability or chatter, and at practically the same power sensitivity afforded on DC. Unit is more compact and saves space.

Suggested Operating Ranges: higher voltages may be used with series resistors mounted with the relay enclosure.

Type 4 MBR	Type 5 MBR
4.0—12.0 volts	4.0—12.0 volts
5.0—35.0 ma.	0.5—10.0 ma.

SIGMA

Sigma Instruments, INC.

Sensitive RELAYS

NEW ADDRESS 62 CEYLON STREET BOSTON 20, MASS.

In this push-button test kit, standard battery types BA-42 and BA-59 are shown in relation to their means of connection. This unit is part of test set IE-10

same standards, permitting simplification of placing orders by one agency for all requirements.

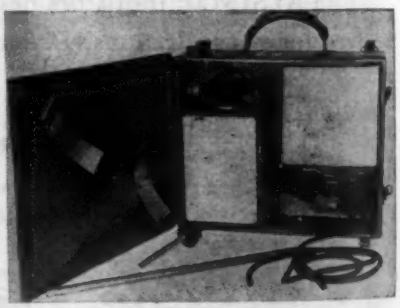
(d) As a result of the intensive program of testing, research, and standardization, there has been a marked improvement in quality and performance of batteries.

(e) Groundwork has been laid for further advances and modifications as may be required for batteries for use in tropical and arctic areas. Already improvements along these lines are well under way.

(f) Stock keeping and issue of batteries is simplified in depots and using areas.

(g) A mass of technical data and experience has accumulated, providing a more definite and scientific approach to the application of batteries for services of all kinds.

The accomplishment of this standardization under the direction of SCSA has included the utilization of much previous work done by such organizations as the National Bureau of Standards and



Besides miscellaneous tools and transceiver handset, case CS-79 contains batteries BA-39 and BA-40. Unit is power source for radio set SCR-509

The Automatic Robot Inspector

CHECKS A CIRCUIT A SECOND!

The accurate, automatic Rotobridge is on a 24-hour schedule in many plants, checking all types of electronic equipment for wiring errors, for resistance and reactance values. Robot-like, the Rotobridge does your bidding—exactly! Want a 10% resistance tolerance here? A 25% capacity tolerance there? You get it with the Rotobridge—as you want it—and no mistake! And when the Rotobridge spots an error, there's no mistake about that either. The instant a defect is detected, the Rotobridge stops dead—winks a warning red eye until its human co-worker records the number of the defective circuit on the inspection tag and pushes the go ahead button.

Vigilant and versatile! Rotobridge answers to both descriptions. You can put it to work on several small sub-assemblies or on a complete set, involving as many as 120 circuits. If you're confronted with the problem of inspecting a 30 or 40 tube equipment, you can put two or three of these tireless robots to work simultaneously. In five minutes—they will check the equipment over for you!

Testing of complex cable harness and transformers is also counted among the varied applications of the Rotobridge. Write for complete details on this and other C. M. L. testing equipment.

COMMUNICATION MEASUREMENTS LABORATORY

120 GREENWICH STREET, NEW YORK 6, N. Y.

The American Standards Association. It has also been aided by efforts of the battery manufacturers and by personnel of the armed forces.

Before the issuance of the specification it had been customary to design each type of battery to the equipment with which it was to be used. Current practice is to design the equipment to use an approved Signal Corps type battery. Signal Corps dry batteries are not standardized for general Signal Corps use but rather for use with individual equipment. The Standards Agency is charged with approval of batteries for each particular use intended and manufacturers may not use other batteries than those so approved.

Prosperity Among Broadcasters

ON THE FIRST ANNIVERSARY of effectuation of FCC chain broadcasting regulations, Chairman James L. Fly announced that broadcasting stations as a whole earned 50 percent more, before income taxes, in 1943 than in 1942.

Specifically, NBC's earnings went up from 137 to 190 percent of the value of its property, CBS from 97 to 158 percent, Blue from 8 percent to 149, and Mutual 59 to 84 percent.

For 1943, 723 stations reported income, while 73 reported losses. Total income was $46,850,189, while total losses were $368,792.

Research for Communications and Radar Leadership

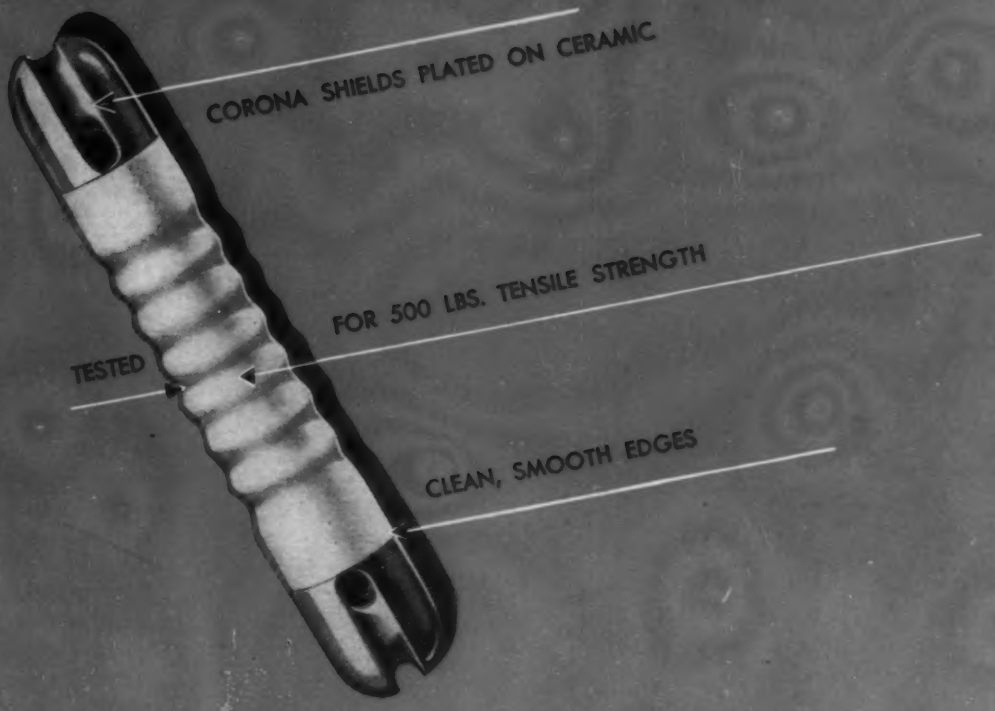
CONTINUOUS RESEARCH is an activity which is keeping this country in the lead in military electronics, according to Major General Harry C. Ingles, Chief Signal Officer, who appeared before a House Committee to discuss his 1945 budget.

The $50,000,000 requested was characterized as essential to development work on low- and high-level blind bombing, blind landing, other air navigational equipment, control equipment for guided missiles, radio counter-measure equipment, radio relay systems and equipment for front line use.

He described American signal equipment as the equal of German

Presenting

A BASICALLY BETTER ANTENNA STRAIN INSULATOR



A development of Bendix Radio* Creative Engineering, this new antenna insulator effectively removes the dangers attendant on loosening of corona shields. The shields *cannot* come loose because they are plated directly on the ceramic—so insolubly bonded as to make a single unit of ceramic and metal. Careful manufacturing processes provide a clean, point free edge on the metal shield to further reduce the tendency of corona discharge.

The result? Well, tested in a pressure chamber duplicating 40,000 feet altitude the Bendix Insulator forced a spark jump of 10 inches between the transmitter and chamber wall without allowing current to cross the insulator.

Baffle-designed to reduce flashover—*and tested to 500 lbs. tensile strength*—this performance-proved Bendix development is now available for general use.

*TRADE-MARK OF BENDIX AVIATION CORPORATION

Bendix RADIO DIVISION

BENDIX AVIATION CORPORATION • TOWSON, MARYLAND

STANDARD FOR THE AVIATION INDUSTRY

Star Performers!
Permoflux Means Progress!
When Permoflux Engineers began developing wartime designs for acoustical communications equipment, old concepts of efficiency stood only as relative measures for improvement. Permoflux contributions, by more than meeting anticipated requirements, have achieved new performance standards of far reaching importance. The value of these developments will be reflected in Permoflux products of the future.
BUY WAR BONDS FOR VICTORY!
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4916-22 W. Grand Ave., Chicago 39, Ill.
PIONEER MANUFACTURERS OF PERMANENT-MAGNET DYNAMIC TRANSDUCERS

apparatus in every way and far superior to Japanese. He said American radar is better than that of Germany.

Savings during the next fiscal year have been made possible by contract terminations and price renegotiations and savings. He observed that signal equipment prices have been reduced approximately 16 percent. Quantity production and increased experience among manufacturers were credited. Price estimates are being made more accurately by the Signal Corps, too, he said.

One type of combat radio had been reduced from $6,370 to $3,729 while one piece of radar equipment, after having been built in considerable number, was cut from $40,000 to $20,000. Component prices have been similarly reduced.

American Transmission to Europe

RADIO ACTIVITIES of the Psychological Warfare Branch of OWI include the establishment and operation of radio facilities to spread our messages on the continent of Europe.

Four 50-kw medium-wave transmitters and at least four powerful shortwave transmitters are beamed to the Continent from points in America, England, North Africa, and Italy.

Thus, reception is practically assured for any listener with a short or medium-wave receiver in any part of Europe. Additional transmitters are in readiness for installation on the Continent.

No listener surveys have been made, but indication of effectiveness is given by the fact that originally severe penalties for listening have been made even most drastic by German occupation authorities.

Conventions to Come

Aug. 29-Sept. 1. Pacific Coast Technical Meeting, Los Angeles, Calif. **American Institute of Electrical Engineers,** H. H. Henline, secretary, 29 West 39 St., New York 18, N. Y.

Sept. 18–20. Eleventh Annual National Conference, Toledo, Ohio. **Associated Police Communication**

"I want A FLEXIBLE GASKET TO WITHSTAND 2000° F." said the airplane part maker

"I want A RUSTLESS, DURABLE PRESSING PAD" said the laundry operator

"I want A FINE TUBE GRID THAT WON'T SAG" said the electronic tube maker

"I want A LASTING WICK FOR AIRPLANE HEATERS" said the cabin heater maker

They found what they wanted in *KNIT MESH* made of INCO Nickel Alloys

Today, metal mesh knit from INCO Nickel Alloys does *all* these varied jobs.

Tomorrow? Perhaps it's the answer to an electronic problem now on *your* drafting board.

For Knit Metal Mesh, product of the Metal Textile Corp., Orange, N. J., has many properties that point to its wide future use in electronics.

Knit from Monel, Nickel or Inconel, it is rustless corrosion-resistant, tough, strong, able to withstand high temperatures. In addition, its special *linked-loop* design is flexible, highly resistant to breakage, unusually strong on the bias. It offers, for instance, a firm fabric for grids because the linked loops allow normal expansion when the grid is heated, and return the fabric to its original shape as the grid cools.

The knit fabric holds together even when made of very fine wire (.0045 diameter), and with as few as 4 or 5 openings to the inch.

For further information about mesh knit from the INCO Nickel Alloys... and for other technical service on metal problems... address: The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.

"I want A BETTER AIR FILTER MEDIUM" said the filter manufacturer

"I want A FLEXIBLE STRAP THAT WON'T JIGGLE LOOSE" said the magneto maker

NICKEL INCO ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • "Z" NICKEL • NICKEL • Sheet...Strip...Rod...Tubing...Wire...Castings

GUARD AGAINST
Insulation Failures
WITH THE HOLTZER-CABOT
Electronic
INSULATION RESISTANCE TESTER

Protect your electrical equipment from possible insulation failures by making periodic tests with the Holtzer-Cabot insulation resistance tester. A self-contained, portable unit weighing only 3 lbs., it is always ready to use in the plant, laboratory or field. The hand crank generator delivers 500 volts D.C. testing voltage ... eliminates batteries and external power supply. Two indicator buttons light up when generator is delivering correct testing voltage. Electronic voltage regulation assures uniform testing voltage over a wide range of cranking speeds. Guard circuit eliminates surface leakage from affecting measurements. Wide range ... 0 to 100 megohms. Scale is spaced for easy reading.

Get the complete story on Holtzer-Cabot insulation resistance tester. Write for bulletin today.

HOLTZER-CABOT
Division First Industrial Corp.
400 STUART STREET, BOSTON 17, MASS.

Officers, Sgt. C. H. Knudel, chairman, 720 Jefferson Ave., Toledo 2, Ohio.

Oct. 2-5. Forty-Ninth Annual meeting, Boston, Mass. **International Municipal Signal Association,** Irwin Shulsinger, secretary, 8 East 41 St., New York, N. Y.

Oct. 5–7. **National Electronics Conference,** Chicago, Ill. B. Dudley, secretary, 520 N. Michigan Ave., Chicago, Ill.

Oct. 12–14. Fall Meeting, Buffalo, N. Y. **Electrochemical Society,** Colin G. Fink, secretary, Columbia University, New York 27, N. Y.

Oct. 16–18. Fifty-Sixth Semi-Annual Fall Conference, New York, N. Y. **Society of Motion Picture Engineers,** W. C. Kunzmann, vice president, Hotel Pennsylvania, New York, N. Y.

Oct. 16–19. Twenty-Fifth Annual Meeting, Cleveland, Ohio. **American Welding Society,** M. M. Kelly, secretary, 33 West 39 St., New York 18, N. Y.

Oct. 19–21. Electronic Parts and Equipment Industry Conference, Chicago, Ill. **Association of Electronic Parts and Equipment Manufacturers; Eastern Div., Sales Managers Club;** and **National Electronics Distributors Association.** H. W. Clough, chairman, PO Box 5070-A, Chicago 80, Ill.

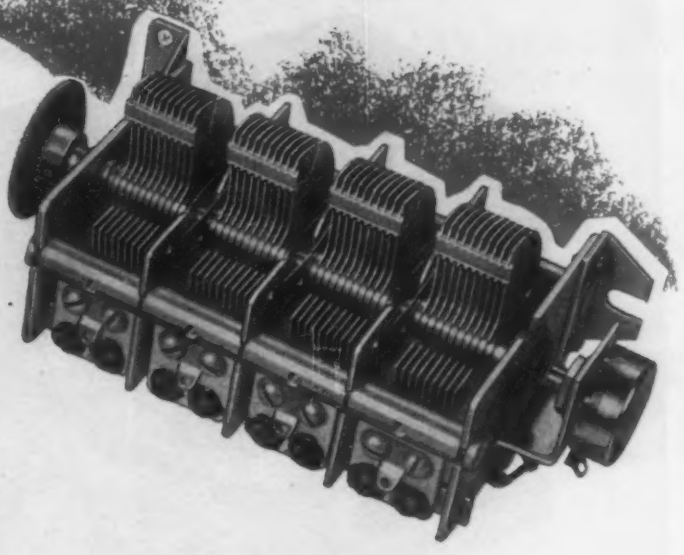
Nov. 2–3. National Time and Motion Study Clinic, Chicago, Ill. **Industrial Management Society.** C. S. Becker, vice president, 205 West Wacker Drive, Chicago 6, Ill.

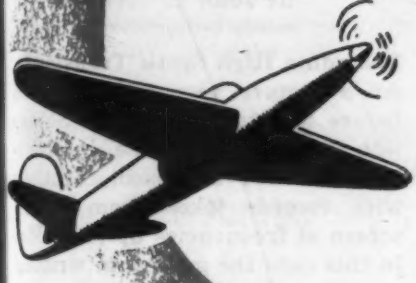
Nov. 13–14. Annual Receiver- and Tube-design Meeting, Rochester, N. Y. **Radio Manufacturers Association** and **Institute of Radio Engineers;** Bond Geddes, secretary RMA, 1317 F St. N.W., Washington, D. C.; Haraden Pratt, secretary IRE, 330 West 42 St., New York 18, N. Y.

Signal Corps Is Pleased

NOTHING HAS BEEN MORE striking than the achievement of the electronic design and manufacturing groups, in the opinion of Major General William H. Harrison, chief of the Procurement and Distribu-

QUESTION: Has your company considered selection of Post-War radio air condensers?





It isn't too soon to plan. And in planning, take into consideration the importance of the air condenser. Recall how very much our armed forces today depend upon communication sets, and the necessity of accurate tuning to get every message distinctly. It is significant that variable air condensers of Radio Condenser Company are used by our armed forces. Why wouldn't they continue to be a good bet after the war? Plan — and use — our air condensers and push button tuning devices in your post-war manufacture of radios.

RADIO CONDENSER CO.

CAMDEN, N. J.

RADIO CONDENSER CO. LTD., TORONTO, CAN.

● Practical filter designs involve important compromises between several related factors if physical specifications and attenuation characteristics are to be achieved for predetermined circuit requirements. The overall performance of any design depends largely upon the carefulness and accuracy with which these considerations are carried out.

Behind every ADC Filter stands years of practical design experience—the type of knowledge that makes it possible to turn out filters for the most exacting service applications.

ADC

Audio Development Co.

2833 13th Ave. S., Minneapolis, Minn.

tion Service of the Signal Corps. He was conveying the thanks of the organization to the industry in a talk before RMA in Chicago recently.

In addition to creating a situation where our invasion forces have lacked no essential signal equipment, the industry is credited with supplying complete equipment for French and Italian units. He substantiated the belief that all of this equipment outstripped that of the enemy in dependability, flexibility, range, and general performance.

Electronic Production Off

WPB ANNOUNCES that communication and electronic equipment fell 1 percent below the level of March production during April and was 3 percent behind schedule. Radio, a declining program, fell 5 percent short. Airborne equipment, a rising program, was 6 percent behind and ship communication and electronic equipment was 4 percent off, while ground equipment was 1 percent ahead.

LONDON NEWS LETTER

BY JOHN H. JUPE
London Correspondent

Recording High Speed Transients. At a lecture recently delivered before the Association for Scientific Photography some interesting data was disclosed, together with records taken from a cro screen at frequencies up to 41 Mc. In this case the maximum writing speed was 3,800 km per sec—1/80 the speed of light—yet the record was quite clear and occupied about 8 complete cycles.

The lenses used were a 2-in. focus with an aperture of $f/1.9$, and a series of 1-in. focus, with apertures ranging from $f/1.9$ to $f/1.4$ There was also a special lens constructed by Taylor, Taylor and Hobson for the Kodak research department with a 2¼-in. focus and an aperture of $f/1$.

In the opinion of W. Nethercot, who conducted the work for the Electrical Research Association, the fastest films were orthochromatic, Kodak R.55 or Ilford 5.G.91. The very slight increase in speed obtained by using panchromatic emulsions was not judged to out-

The I-S SPRINGBOARD

VOL. 1 NO. 1

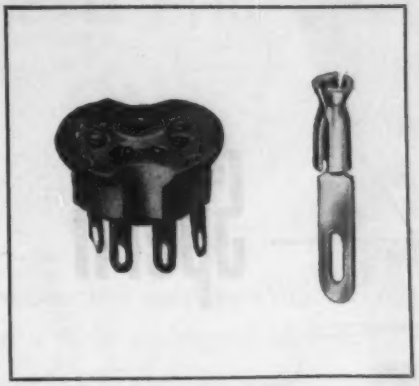
Published by INSTRUMENT SPECIALTIES CO., INC.

258 BERGEN BOULEVARD — LITTLE FALLS, NEW JERSEY

FILEWORTHY FACTS ABOUT MICRO-PROCESSED BERYLLIUM COPPER

OUTSTANDING TUBE SOCKET PERFORMANCE DIRECT RESULT OF MICRO-PROCESSED BERYLLIUM COPPER

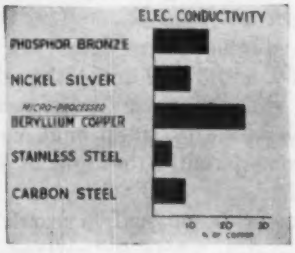
Instrument Specialties is producing in large quantities a new tube socket contact which assures uniform, constant pressure on the tube pins under conditions of extreme vibration and temperature. This contact was designed to take full advantage of beryllium copper, permitting intricate forming prior to heat treatment, and SELECTIVE HARDENING, a new heat treating technique. The spring end of the contact is hardened to a tensile strength of 180,000 lb. per sq. in. (Rockwell 15N-80) for maximum stability, and the tab end is heat treated to 60,000 lb. per sq. in. (Rockwell 15N-40) for ductility and ease of soldering leads.



These micro-processed beryllium copper contacts have maximum vibration stability, minimum drift under load, and high conductivity, giving low electrical losses.

The entire socket, produced by H. H. Eby, Inc., Philadelphia, was made to specifications and designs of the Signal Corps Laboratory, Ft. Monmouth, N. J.

Micro-Processed Beryllium Copper Has Highest Conductivity Of all Spring Materials



Before heat treatment, the conductivity of Beryllium Copper is the same as phosphor bronze. Conductivity increases during heat treatment, and response varies with each lot of material. Micro-processing is the only sure way of obtaining the value shown above, and at the same time reaching maximum overall spring properties. Still higher conductivity values are obtainable at some sacrifice in other properties.

BRUSH SPRINGS WITHOUT SHUNTS SAVE UP TO 30% ON ASSEMBLIES

Beryllium Copper^{mp}, with its high conductivity (see chart) and ability to stand 100°F higher working temperature, plus closer tolerances on the ID has eliminated the need for pigtails on brush springs in many light duty applications. I-S unshunted brush springs are far easier to assemble, give longer service life at peak loads, and assure constant, even pressure at all times. Send drawings to I-S or write for I-S brush spring data sheet.

One order for 1,250,000 contact coil springs is being micro-processed by I-S at the rate of 250,000 per week.

WHAT DOES 200,000 LB. PER SQ. IN. TENSILE STRENGTH MEAN IN SPRING PERFORMANCE?

The higher strength of Certified "Silvercote" Beryllium Copper wire used in I-S coil springs allows a 25% increase in design stress over ASTM spec. wire. This makes it possible to design a satisfactory spring in a smaller space, and also greatly increases life under endurance service. Resistance to drift is increased 5 to 20 times, an important advantage in a variety of every-day spring applications.

LITERATURE

DO YOU HAVE ON FILE?

Recent technical article by Sheldon Klock, I-S Field engineer, points out contributions of Micro-processing in improving performance of electronic equipment, and accomplishing results impossible with conventional spring materials. Write for your copy today.

FROM THE I-S LABORATORY

Cleaning Beryllium Copper Springs in Preparation for Soldering and Electro-Plating

Two standard cleaning methods that give excellent results on Beryllium Copper:

1. Sulphuric-Bichromate Pickle
   - sulphuric acid .....1 gal.
   - water .....4 gals.
   - sodium bichromate..3 ozs. per gal.
   - temperature .....140°-180° F
   - time .....½ to 10 mins.

   Parts should be agitated in solution to insure uniform attack. Time should be kept to the minimum needed to prevent loss of spring pressure and to avoid pitting. Rinse with cold water.
2. Bright Dip

   Solution #1 may be used cold as a bright dip or a typical bright dip as follows may be used:
   - sulphuric acid .....2 gals.
   - nitric acid .....1 gal.
   - water .....1 qt.
   - hydrochloric acid..1 oz. per 5 gals.
   - temperature .....cold
   - time .....5 seconds to 5 mins.

   Rinse in cold water followed by a hot water rinse to aid in rapid drying.

   Parts having a very light oxide surface such as results from salt bath heat-treatment, may be satisfactorily cleaned by using only the bright dip solution. Such parts will then readily electro-plate or solder.

look ahead

and look to Sperti

EVEN with the rapid advancement of science, spurred by war demands, we have seen only a glimpse of what lies beyond the uncharted horizons.

The contributions which Sperti has made in the field of electronics, irradiation and fluorescent lighting (as well as biodynes with all they imply in the field of medicine) are but a promise of significant *new* developments to come.

For beyond Sperti are laboratories devoted to pure research . . . staffed by scientists whose sole purpose is to unselfishly roll back the horizons of human knowledge for the betterment of mankind.

Sperti, Inc. exists to make their mature discoveries available in applicable form.

Even now, though Sperti is almost wholly engaged in war work, there may be a discovery which has a place in your postwar product planning.

It will pay you to keep Sperti in mind—as you turn *your* mind toward tomorrow.

Sperti INCORPORATED

RESEARCH • DEVELOPMENT • MANUFACTURING • CINCINNATI, OHIO

weigh the additional difficulties encountered. Recommended developers were Kodak D.19b and Ilford I.D.33, followed in some cases by treatment with uranium intensifiers. For paper prints, high contrast papers such as Kodak BG.4 or 5, or Velox VG. 5 were used with very good results.

Needless to say, only small negatives could be obtained, as, without very bulky camera equipment, the lens must be near the oscillograph screen, with consequent reduction in its depth of focus. Defocussing due to curvature of the screen and distortion due to the trace being at the edge, set further limits but a 5-in. screen was found to have a useful working area about 4 in. in diameter.

Placing the film in direct contact with the screen produced fairly satisfactory results up to about 6 Mc but the results using a camera were far better. This method was adopted for most of the work, which represents a big advance in the recording of high speed transients at reasonable cost and without undue difficulty.

Police and Fire Radios Separated

CITIES WHOSE FIRE DEPARTMENTS serve a population of 150,000 or more and smaller localities with special problems are eligible for special municipal fire frequencies, independent of their police channels, according to the terms of a recent act by FCC.

Available frequencies are 1630, 35580, and 37740 kc. Although only one vhf will normally be assigned to any locality, additional ones can be considered in the light of special needs.

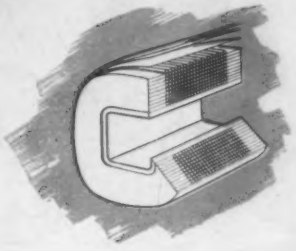
Power, in general, is restricted to 250 watts, while authorized types of emission are: A-1, A-2, and A-3 on 1630 kc; A-1, A-2, A-3, A-4, and special emission for fm on 35580 and 37740 kc.

How Television May Grow

AUDIENCES FOR FUTURE TELEVISION entertainment may get their first taste by blind listening to the audio components of television broadcasts if the predictions of Leonard

Anaconda Paper Section Coils

...all standard and special types



THE PAPER SECTION construction used by Anaconda is exceedingly flexible and a wide variety of coils can be made by this method. Standard Paper Section Coils may be wound on round, square or rectangular cores. The thickness of the inner layer of the paper is especially selected to suit the size of wire used for the winding.

In addition, special types of Paper Section Coils are designed for high voltages, ranging up to 85,000 volts or more, such as in the case of X-ray transformers.

Anaconda High Voltage Paper Section Coils are made with special methods of insulation and construction to accommodate high potentials. For example, the paper margin is substantially larger; the number of inter-layer paper wraps is graded throughout the coil; the inner and outer layers of wire are usually wound with increased pitch to separate the individual turns; the type of paper used is carefully selected to meet specific conditions.

Paper Section Coils are one of the many fine *engineered* products of Anaconda. Any of our sales offices will be glad to refer inquiries to our coil engineering staff. 44228

Magnet wire and coils

ANACONDA

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★ No need to crystal gaze into the future of electronics. For, as we at National Scientific Products Company engage in secret wartime electronic developments, many peacetime applications of these very same electronic principles are revealed daily.

New, cost-saving electronic designs which are applicable to post-war products ranging from radios, lighting units, thermal devices, timing and measuring instruments, electrical-therapy machines and door openers, to a host of other peacetime items, are everyday occurrences in National laboratories.

If your post-war product incorporates a tube, singly or in combination with an electrical control, or other electronic or electrical unit, we are prepared to make specific recommendations to bring it to maximum efficiency.

Write today. Your inquiry will receive prompt attention.

Electrical and Mechanical Engineering

NATIONAL SCIENTIFIC PRODUCTS COMPANY

Designers and Manufacturers of Electrical and Mechanical Devices

5013-25 NORTH KEDZIE AVE., CHICAGO 25, ILLINOIS

Cramer, vice president of Du Mont Laboratories, come true.

Speaking at a recent meeting of the Television Press Club of New York, he suggested that many of the present differences of opinion might be settled through the mountain-into-molehill effect of a tuning device which permits continuous tuning over a wide frequency range. This development, the Mallory-Ware Inductuner, makes it feasible for immediate postwar f-m sets to cover the television audio channels as well as their own.

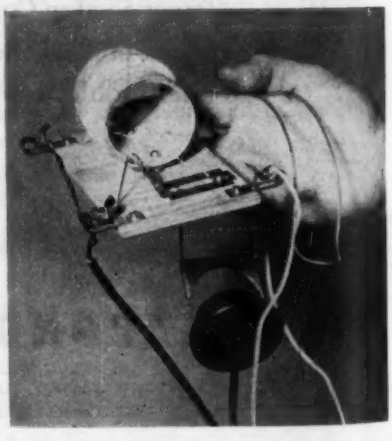
Then, having had a taste of television, the listener would aspire to add a separate video unit which, could be made available for $75 or less. Future developments, such as the addition of color, and changes of standards would thus be more easily and inexpensively achieved. Mr. Cramer envisioned the final top-bracket receiver as a unit combination of television sight and sound, fm, am, and phonograph with a price somewhere between $500 and $1000. Such a device would be the evolutionary outgrowth of the piecemeal system and would be considerably longer in coming.

Razor-Blade Radios

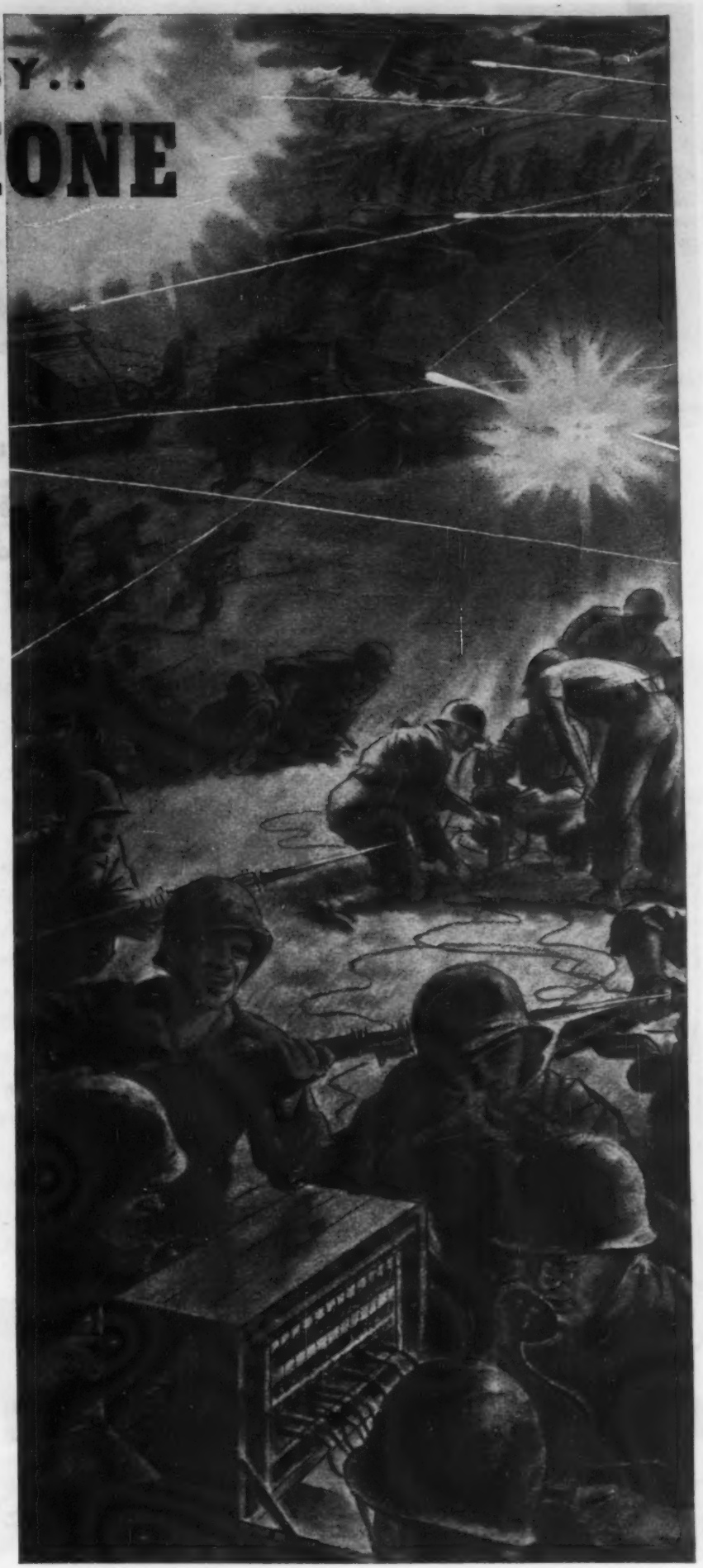
IN NEW YORK RECENTLY, Marlin Firearms Co. was startled to hear that its blued-steel razor blades were in considerable demand on the Italian front as components for portable radio receiving sets.

In a letter from Lt. Maxie L. Rupert, Anzio, details of the receivers were provided, together with a wiring diagram.

Further development is apparently under way as engineers of Na-



INVASION BY..
TELEPHONE



According to War Department records, rehabilitation of 49,176 wire miles of communications was accomplished by the Signal Corps in Sicily alone.

The magazine, "Steel", comments on the fact that wire communication remains basic in this zone. It enjoys the advantage of a degree of security not enjoyed by other mediums. The editor of "Steel" points out that the demand for wire field communications will continue to be heavy until the wars in both major zones are won.

Imagine the demand for field telephone equipment with the whole continent of Europe under invasion, and Pacific operations constantly expanding!

The men and women of Connecticut Telephone & Electric Division, commended personally by War Manpower Commissioner McNutt for their splendid record in turning out field telephones and other basic communications equipment, realize their ever-increasing responsibilities. They are determined to fulfill this obligation to our armed forces and those of our allies.

CONNECTICUT
TELEPHONE & ELECTRIC
★ DIVISION ★

GREAT AMERICAN INDUSTRIES, INC.

MERIDEN CONN.

G.A.I. divisions are producing for the war effort: Military Trucks, Fire Apparatus, Communications and Electronic Equipment, Aircraft Ignition Components, Cellular Rubber Products.

still delivering after

88,000 HOURS

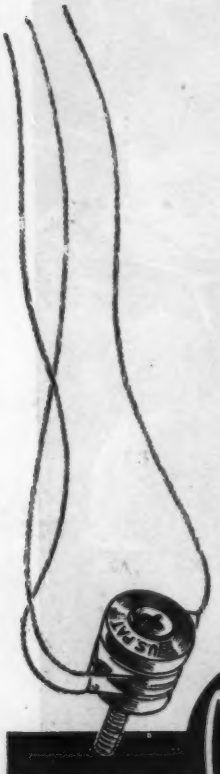
Continuous Service

This Conant type M rectifier was returned as defective on May 9, 1934. When routine tests failed to show any defects, this rectifier was mounted on the back of a 15 mil meter and put in operation as a line voltmeter, in an effort to detect any intermittent condition.

For more than ten years this "defective" Conant rectifier has been in *continuous service*—an estimated 88,000 hours—delivering a full 13 milliamperes, its original output. This is the milliampere-hour equivalent of several lifetimes of normal service.

This unintentional life test, begun a decade ago, makes it possible to safely predict a normal life of at least ten years for any Conant rectifier.

If it is important that your instruments retain their initial calibration *for life*—choose Conant rectifiers and be *certain*.



Instrument Rectifiers

CONANT ELECTRICAL LABORATORIES

6500 O STREET, LINCOLN 5, NEBRASKA, U. S. A.

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4018 Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal.
4205 N.E. 22nd Ave., Portland 11, Ore.
Caixa Postal 930, Sao Paulo, Brazil
50 Yarmouth Rd., Toronto, Canada

tional Broadcasting Co. made a test unit from details of the letter, suggesting that improved reception might be brought about by substituting a short piece of pencil lead for the steel contact point of the safety pin detector. The receiver illustrated here is the latter, Model 2.

Study of Automobile Interference

WORKING IN COOPERATION with the Society of Automotive Engineers, the Engineering Department of RMA is undertaking a series of tests to determine details of automobile interference with television and f-m reception. Five thousand dollars has been appropriated for the project.

Soviet Electronic Plant

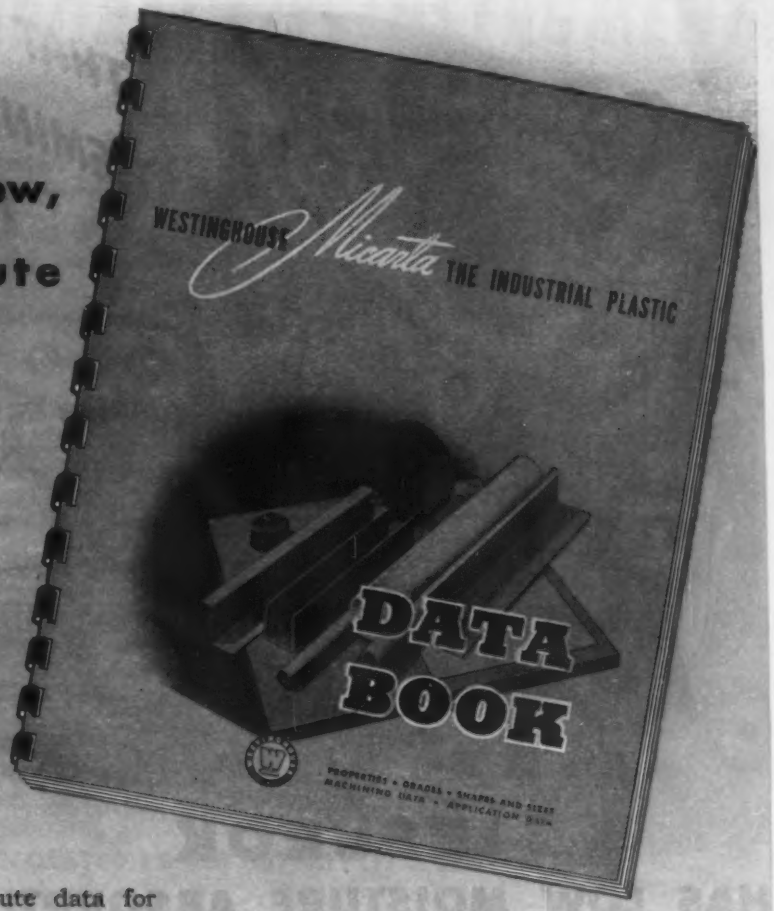
PRODUCTION AND ENGINEERING departments of some of the newer Russian electronic plants are doing work which compares very favorably with some large American organizations, in the opinion of Ray C. Ellis, director of the Radio and Radar Division of WPB, who recently returned from a two months visit to the Soviet Union. Speaking before the Third War Production Conference of RMA in Chicago recently, he gave an account of some of the impressions he had received.

The Russian radio industry before the war was very small, with sets and parts produced in about fifteen factories. Development work originated with a central government planning agency, which was primarily interested in high-power transmitters, television, and special tubes. There were two experimental television stations in operation.

Little work was done on receiving tubes, shortwave sets, high fidelity, fm, loudspeakers, or component parts. Foreign contact by their engineers was kept to a minimum and few outside radio men were allowed inside Russia.

Between June and October, 1941, because of the German invasion, all of the radio industry was evacuated from western Russia to central Siberia, over 2,500 miles away. Here temperatures vary more than anywhere else in the world, changing from 100 deg F in summer to −50 in winter. Despite this and compli-

40 pages of new, up-to-the-minute *facts* FOR COMMUNICATIONS ENGINEERS



Here's new and up-to-the-minute data for designers of communications and electronics equipment in concise, easy-to-use form.

Forty pages of property tables, performance curves and design suggestions provide working data for selecting the proper grade of Micarta for any communications application. Data covers both laminated, molded, and formed Micarta. Grades include those designed for severest wear and high dielectric strength. Micarta terminal blocks, commutators, bases, coil forms, switch spacers and tube sockets, are now standard in the industry. In these successful applications, you may find the basis for an improved design.

Reserve your copy of the new Micarta Data Book today. Write Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N. J-06354-1B

GET THIS HELPFUL DATA:

Grades of Micarta—their characteristics . . . corresponding Army and Navy types.

Properties of Micarta — electrical . . . mechanical . . . chemical . . . how they compare with other materials.

Designing Help—machining data . . . how to apply directional loads . . . molded and formed Micarta design suggestions.

Forms Available—standard shapes and sizes . . . plates, rods, tubes, angles, channels, zees.

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INSUROK
HAS LOW MOISTURE ABSORPTION"

THE dangers of damage from moisture and corrosion are minimized when INSUROK is used. And, in addition, it has the stamina to absorb shock and to stand up under rough handling.

It is not strange, therefore, that both Molded and Laminated INSUROK are being widely used in war products—are being specified for use in many types of products for tomorrow.

There are many grades and types of Laminated and Molded INSUROK, with a wide range of chemical, electrical and mechanical characteristics. One or more types of INSUROK will meet practically every requirement.

Richardson Plasticians have had years of experience in working with designers and manufacturers. They will be glad to help you determine the grade best suited to your needs. Write for complete information.

Every day, parts and products made of Laminated or Molded INSUROK are successfully meeting all kinds of moisture and temperature conditions. Be sure to get the facts about this and other characteristics which are causing INSUROK to be specified for so many types of products.

INSUROK *Precision Plastics*

The RICHARDSON COMPANY

MELROSE PARK, ILL. NEW BRUNSWICK, N. J. FOUNDED 1858 INDIANAPOLIS 1, IND. LOCKLAND, CINCINNATI 15, OHIO
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cations involved in housing shortages and plant inadequacies, shipments of equipment began four months after the move.

One tube plant employs 2,000 persons and makes several types of metal tubes. Glass tubes are also made, including glass power tubes, acorn tubes, water-cooled power tubes up to 100 kw, rectifiers and x-ray tubes. All are skillfully hand built, including the glass blowing.

Test equipment of all types was lacking, lighting facilities were poor and safety devices meager. Nevertheless, the spirit with which production quotas are strived for exceeded the sort of thing generally demonstrated in American plants. About 85 percent of the employees are characterized as a serious-minded group of women, ranging from 14 to 55 years of age.

Recently some of the plants were moved back to the west into modern buildings which incorporate latest production knowledge. These buildings include elaborate precautions against bombing and gas attacks. In one particular plant visited, the organization followed closely those principles accepted in America. While production and engineering activities compared favorably with ours, personnel and incentive departments are considerably ahead of those in many of our plants.

Television Picture Quality

EVEN IF THERE were no basic change in television standards immediately after the war, there would be possible an appreciable improvement in the quality of the picture produced, in the opinion of Allen B. DuMont. Speaking before one of the sessions of the Television Seminar of Radio Executives Club in New York, Mr. DuMont pointed out that most of the receivers in existence are of rather old vintage and not capable of translating more than 250 lines of the transmitted 525 into a useful picture.

Contrasting television details with those of motion pictures, he showed that from the viewpoints of flicker frequency (60 to 48 per sec.) and intensity (20 to 12 foot lamberts), television had the advantage. As for comparative numbers of picture elements, 35 mm film has

A PRECISION LABORATORY INSTRUMENT

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U. H. F. SIGNAL GENERATOR MODELS 804-CSI

also 804-CS2

FOR MORE DETAILED INFORMATION WRITE TO DEPT. E-8

Carefully and difficultly acquired experience enabled **Federal** to produce more Ultra High Frequency Test Signal Generators than were ever thought possible—and quickly, too.

Breaking the tightness of demand by the Army and Navy, these high quality laboratory precision instruments are available to research laboratories and industrial manufacturers engaged in the production of electronic equipment.

Your inquiries are invited.

CARRIER FREQUENCY RANGE: 7.6 to 330 megacycles plus or minus 2%, direct-reading in 5 bands, 6th band available for use with blank coil form supplied.

OUTPUT VOLTAGE RANGE: Calibrated Attenuator continuously variable from 1 to 20,000 microvolts, accuracy plus or minus 10%.

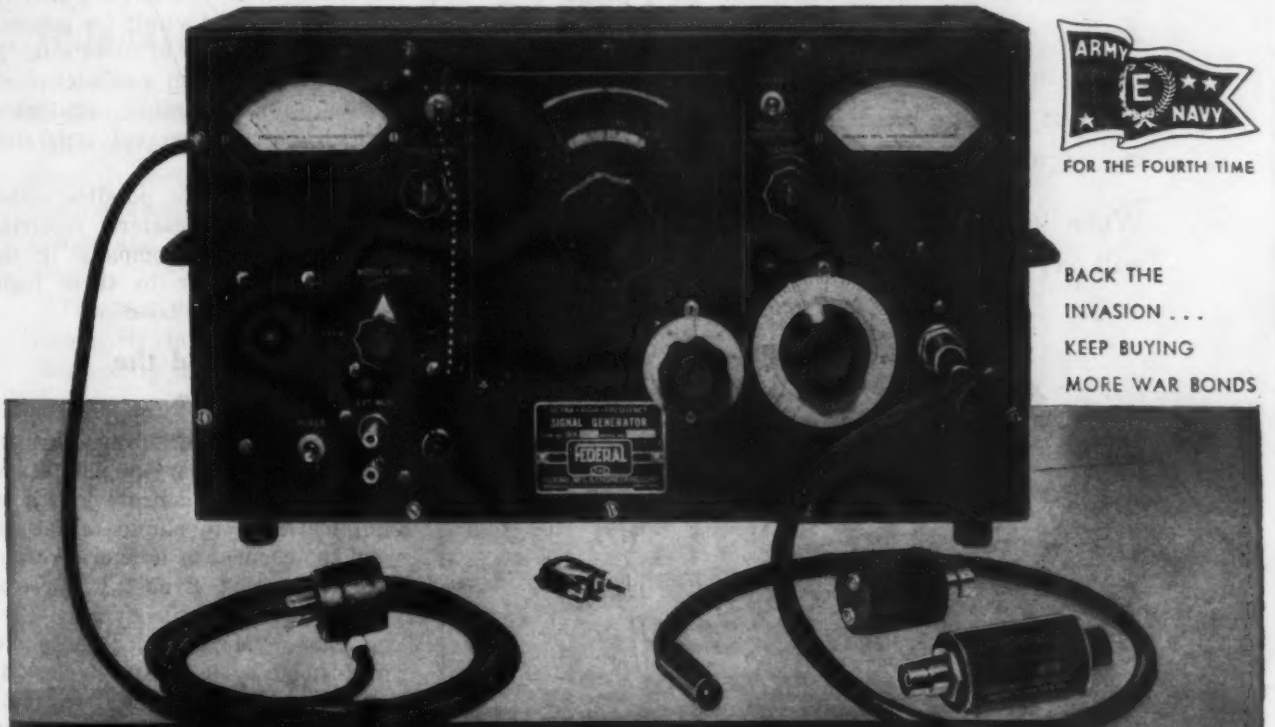
MODULATION: Internal Modulation 1,000 cycles; external modulation up to 20,000 cycles; 0 to 60% direct-reading modulation meter.

STRAY FIELD LEAKAGE: Held to a minimum by Improved shielding and R.F. Filters.

VIDEO OR PULSE MODULATION: Can be pulse modulated externally with signals having very steep wave fronts.

VOLTAGE REGULATED POWER SUPPLY: 115 or 230 volts, 40 to 60 cycles, single-phase.

Manufactured by arrangement with the General Radio Company of Cambridge, Massachusetts, and in accordance with their designs.



ARMY E NAVY

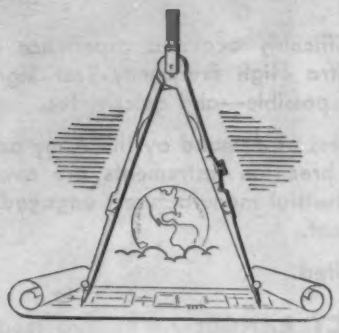
FOR THE FOURTH TIME

BACK THE INVASION . . . KEEP BUYING MORE WAR BONDS

Federal Manufacturing and Engineering Corp.

Manufacturers of Federal Photographic Equipment and Federal Electronic Devices

BROOKLYN 5 NEW YORK



BLUE PRINTING THE

future

Day in and day out the grim demands of war call for more and more engineering ingenuity. More than ever "necessity is the mother of invention".

Apace with this constant wartime pressure, Temple engineers have gone far in the field of electronics. Almost overnight new ideas or new methods give birth to new developments in vital war equipment—give birth, likewise, to blue prints for the vast commercial requirements at war's end.

When it comes to peacetime electronics it will pay you to "team up with Temple".

Temple

Electronics Division

TEMPLETONE RADIO COMPANY

Mystic, Conn.

about ½ million while 525 line television has about half as many. However, only theater projection of the television picture might take full advantage of additional definition.

Two of the recent developments which will make better reception of television pictures possible are flat-faced tubes, which aid contrast, and tubes with black screens, which reduce halo effects. Referring to the probable size of screen in post-war receivers, Mr. Dumont thought that 20-in. would be the maximum, with the flat-type, 16-in. a more popular top size because of its more practical aspects with regard to cabinet mounting.

Beachhead Press Communication

FOR THE FIRST TIME in history, the press has its own radio communication service directly behind the battle lines in Normandy. Special equipment previously prepared by Press Wireless is capable of sending and receiving all varieties of radio traffic, including broadcast services.

Besides a semi-permanent station, the European press crew has a truck with transmitting and receiving sets and a unit for generating electric power to operate it. In this unit are both radio-telephone and radio-telegraph equipment which can be operated separately or simultaneously.

Transmission is possible either directly to the eastern receiving terminal of the company in the United States or to their high-speed channels in London.

Electronics and the Automatic Age

MODERN, MULTI-ENGINED bombers constitute the most complete examples of complex, delicate jobs done automatically to eliminate fatigue and the element of human error, in the opinion of Ernest R. Breech, president of Bendix Aviation Corporation. "More varied tasks are performed by scientific means inside the compact airframes of military aircraft than in any other space of comparable size," he stated, in the course of a display of Bendix-engineered apparatus at Teterboro, N. J., recently.

At the same time, intensive train-

Relentless RESEARCH

FOR BETTER ELECTRICAL CONNECTORS

Section of Burndy's test laboratory

...FOUNDATION FOR Burndy's LEADERSHIP

At Burndy, the development even of a small, special connector, means more than mere drawing board technique. It starts right from *bed-rock* . . . because only through complete laboratory findings on materials, design, and performance, can service efficiency be assured.

The constant, relentless research here in Burndy's completely equipped laboratory explains why so many outstanding connector developments stem from this source . . . and why industry relies on Burndy for the correct solution to any connector problem. Feel free to use this service at any time!

Hydrostatic Chamber

Vibration Machine

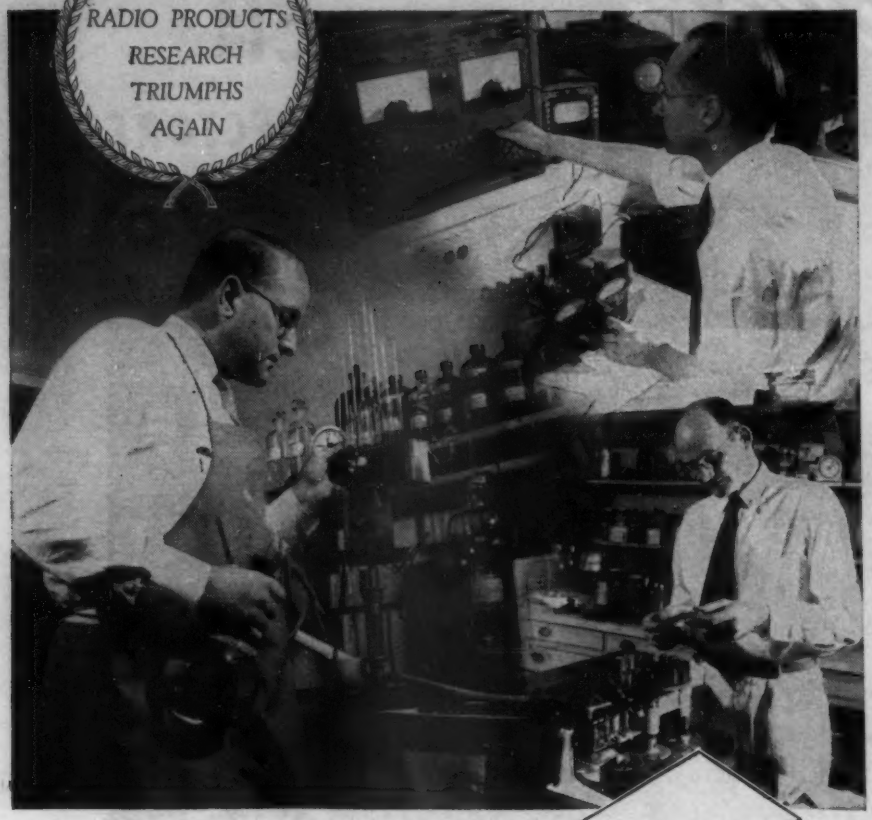
Corrosion Chamber

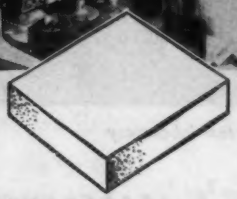
Headquarters for CONNECTORS

Burndy

BURNDY ENGINEERING CO., INC.
107 BRUCKNER BOULEVARD, NEW YORK 54, N. Y.
IN CANADA: Canadian Line Materials, Limited, Toronto 13

SCIENTIFIC
RADIO PRODUCTS
RESEARCH
TRIUMPHS
AGAIN





Another Wartime Development

For a Better Tomorrow

Research at Scientific Radio Products Company is a never-ending search for faster, more practical methods of producing precision-made radio crystals and for developing new and better post-war products.

Latest development of our research laboratory engineers is the perfection of a new and revolutionary method of depositing metal film electrodes directly on quartz plate . . . metal film electrodes that will withstand boiling, scrubbing and extreme temperature ranges from minus 50° to plus 90° C. Now, with this new process, we are able to provide radio crystals with even greater stability of performance under the most adverse conditions.

Nearly all the radio crystals we can turn out go directly to the armed forces to serve our nation as the heart of wartime communication. Tomorrow, crystals will assume their civilian role of advancing our civilization in a world of peace and security. Your plans for postwar progress may include the development of equipment in which crystals play an important role. We will be glad to work with you on any problem.

WRITE FOR NEW BROCHURE

Would you like to read the interesting story of the development of the American crystal industry? Send for your copy of our new brochure. It's as interesting as a tour through our plant. Yours for the asking.

Scientific Radio Products Company

ARMY ★ E NAVY

738 W. BROADWAY, COUNCIL BLUFFS, IA

LEO MEYERSON W9GFQ
E. M. SHIDELER W9IFI

MANUFACTURERS OF PIEZO ELECTRIC CRYSTALS AND ASSOCIATED EQUIPMENT

ing has given large numbers of Americans new education in electronics and other forms of science. He feels that this combination may herald a remarkable advance for technology as applied to private lives after the war.

Substantial Radar Research

PROJECTS PLANNED for 1945 by the Office of Scientific Research and Development (OSRD) total 23 special developments for the armed services with a total allotment of $105,625,000. Of this, radar work received $35,300,000, within $100,000 of expenditures for 1944. Radio coordination rated $12,700,000—$1,000,000 less than 1944, and electrical communication was allotted $500,000, one-half the previous figure.

Terminations to Accelerate

PREVIOUS FIGURES show that cases of Signal Corps contract terminations with claims to exceed $10,000, average 8.7 months for settlement. Of this time, six months is required by the contractor to submit his claim.

Speaking at a luncheon meeting during the recent RMA Convention, Colonel William M. Mack, Director of Procurement, Army Signal Corps, said that efforts will be made to reduce this time to something like 90 days from termination notice to final agreement.

Activities in January covered 140 contracts involving a value of about $19,000,000, while in May, 255 contracts valued at $50,000,000 were closed.

Radio in Europe

EVEN THOUGH the German authorities have made strenuous efforts to confiscate radio receivers from the people of Europe, appreciable numbers of sets are still known to be in the hands of patriots.

All sorts of subterfuges have been followed. Old radios have been turned in while good ones were kept, and conspicuous outside antennas have largely given way to bed-spring aerials.

Allied broadcasts to Europe have provided specific instructions on construction, maintenance, and repair of sets. For instance, a recent OWI broadcast in French sug-

THE WAR WILL END ON

(YOU FILL IN THE DATE)

Think of it! You as a civilian have the power to decide when the war will end. Use that power to the utmost—NOW—by

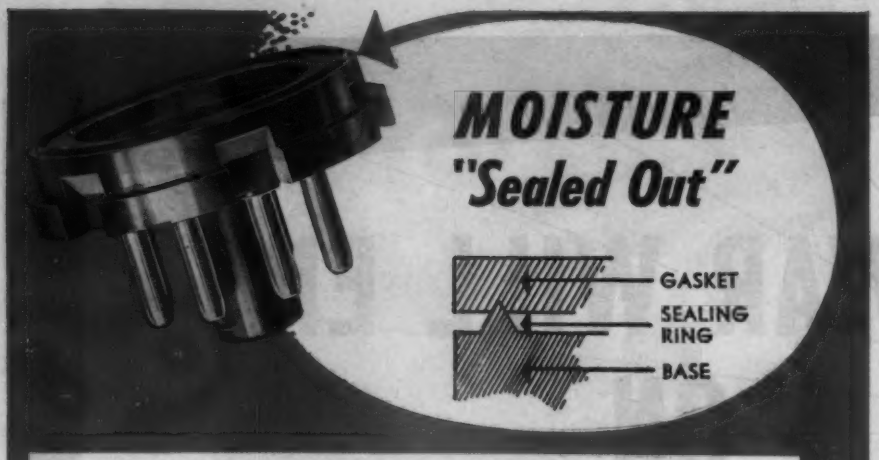
1. Buying war bonds to the limit of your capacity.
2. Working harder, longer, and uninterruptedly turning out implements of war.
3. Donating your blood to the Red Cross to save lives on the battle field.
4. Collecting waste paper and other scrap for which the government is asking.
5. Avoiding black markets as you would the plague. (Black markets cause the plague of inflation.)

All of these are weapons of war—weapons that strike terror in the hearts of our enemies. Use them.

We, the management and employees alike, at Kenyon, are building better transformers than we ever built before—and building them faster for the armed forces.

THE MARK OF EXCELLENCE

KENYON TRANSFORMER CO., Inc. 840 BARRY STREET NEW YORK, U. S. A.



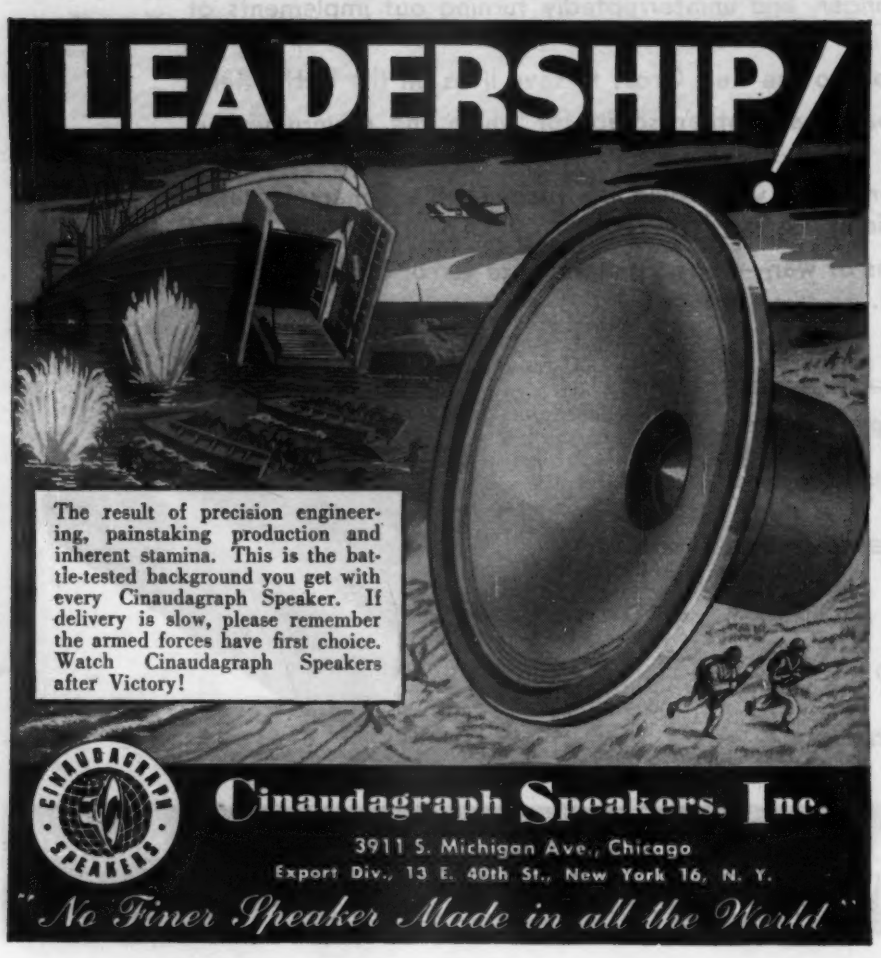
Moisture Proof
OCTAL-TYPE BASE

HOWARD'S Octal-type base keeps out all moisture and dirt, in spite of contraction and expansion caused by heat and cold, by means of a gasket seated on a sealing ring. Designed for radio tubes, crystal holders, transformers, electrolytic condensers, and practically all types of plug-in equipment, this base is made in natural or black Bakelite and has *molded-in pins*. Write today to HOWARD for prices!

★ BUY WAR BONDS ★

HOWARD MANUFACTURING CORP.

COUNCIL BLUFFS, IOWA


LEADERSHIP!
The result of precision engineering, painstaking production and inherent stamina. This is the battle-tested background you get with every Cinaudagraph Speaker. If delivery is slow, please remember the armed forces have first choice. Watch Cinaudagraph Speakers after Victory!
CINAUDAGRAPH SPEAKERS
Cinaudagraph Speakers, Inc.
3911 S. Michigan Ave., Chicago
Export Div., 13 E. 40th St., New York 16, N. Y.
"No Finer Speaker Made in all the World"

gested the organization of collective listening groups including at least one radio technician and possessing at least one receiver. It was also suggested that tubes and parts of old sets be kept for a community stockpile. Then, whenever anyone is compelled to turn over a radio receiver to the authorities he can take out the good tubes and put bad ones in their place before doing so.

Standardization of Hook-up Wire

ATTENTION OF EQUIPMENT manufacturers is directed to the two new specifications which cover radio hook-up wire. Published by the Signal Corps of the Army and the Bureau of Ships of the Navy, the two standards do not differ from each other greatly. Both are performance specifications broad enough to permit the development of other types of insulations, and also to allow the use of several different kinds of materials now available.

Copies of the Signal Corps standard can be obtained from the Signal Corps Standards Agency, 12 Broad St., Red Bank, N. J. Preliminary drafts of the Navy standard have been sent out for industry comment only.

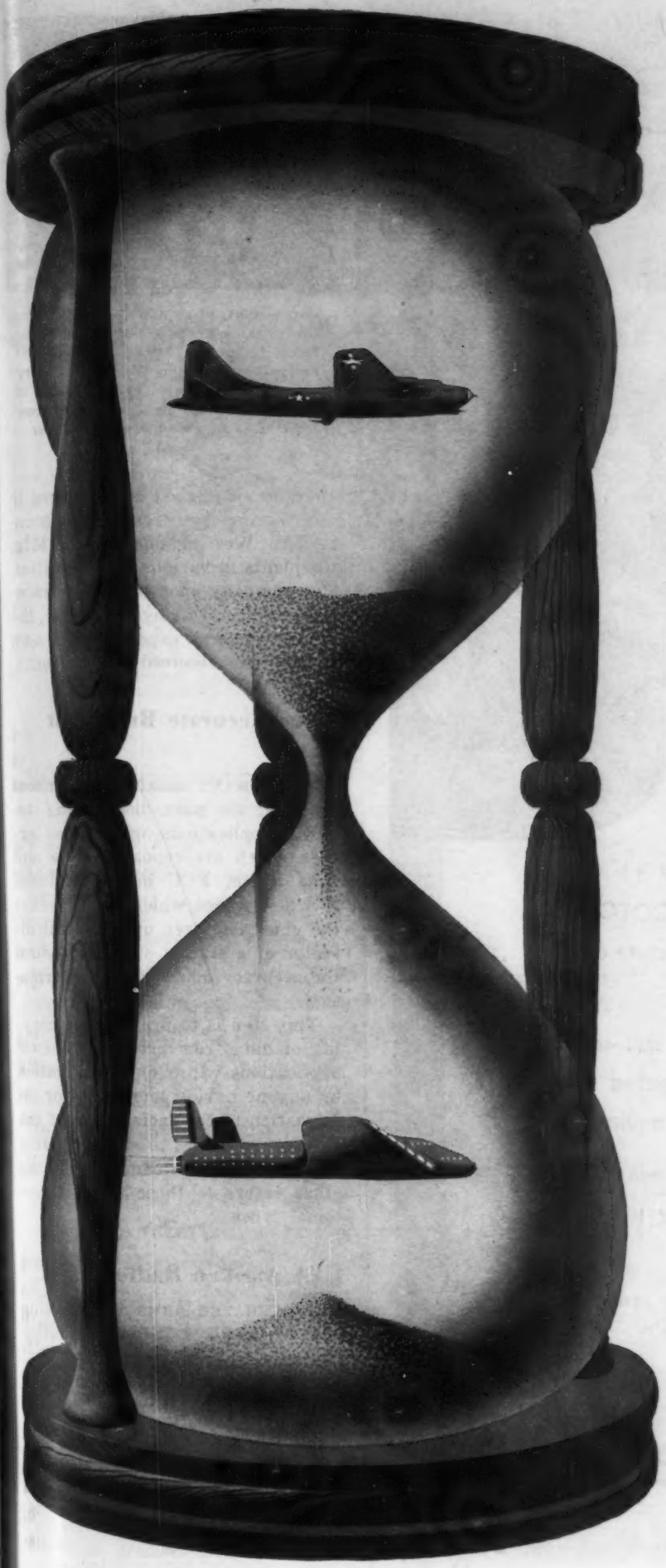
British Television Standards

IMAGES WITH 800-line definition and color are being recommended for English television by one British manufacturer, Pye, Ltd. Television activities of this company were formerly under the direction of Dr. Peter Goldmark, television specialist of the Columbia Broadcasting System here.

Women Engineers Ready

RANGING IN AGES from 18 to 29, a group of 33 women have just finished a special nine-month engineering training course at Carnegie Institute of Technology. They are prepared to act as engineering assistants, participating in the design of electrical equipment, in research work, in analysis and testing, writing specifications, and compiling engineering reports.

Selected from 275 candidates,



WILCO facilities Expanded to Meet Wartime Needs!

But Postwar Industry will be the ultimate gainer from the many new WILCO products and developments

Thermostatic Bimetals, Electrical Contacts, and Precious Metal Bimetallic Products are such important factors in the precision performance of ships, planes, tanks, guns, and various instruments of the Army and Navy that the H. A. Wilson Company has found it necessary to enlarge its facilities and develop many important new products and techniques.

Though now chiefly applied to the war effort, these new Wilco developments are destined to play as vital a role in the postwar industrial "comeback" as they are now playing in scores of wartime applications.

At the coming of peace, the skill and experience gained in the development and application of these new Wilco products and techniques will mean much to automotive, electrical appliance and many other types of manufacturing customers. No company will then be better equipped to meet individual requirements for Thermostatic Bimetals and Electrical Contacts on any desired scale than the H. A. Wilson Company, pioneers in this field.

WILCO PRODUCTS ARE: *Contacts*—Silver, Platinum, Tungsten, Alloys, Sintered Powder Metal. *Thermostatic Metal*—High and Low Temperature with new high temperature deflection rates. *Precious Metal Collector Rings* for rotating controls. *Silver Clad Steel. Jacketed Wire*—Silver on Steel, Copper, Invar, or other combinations requested. *Silver Clad Steel. Rolled Gold Plate. Special Materials.*

THE H. A. WILSON COMPANY

105 Chestnut Street, Newark 5, New Jersey

WILCO

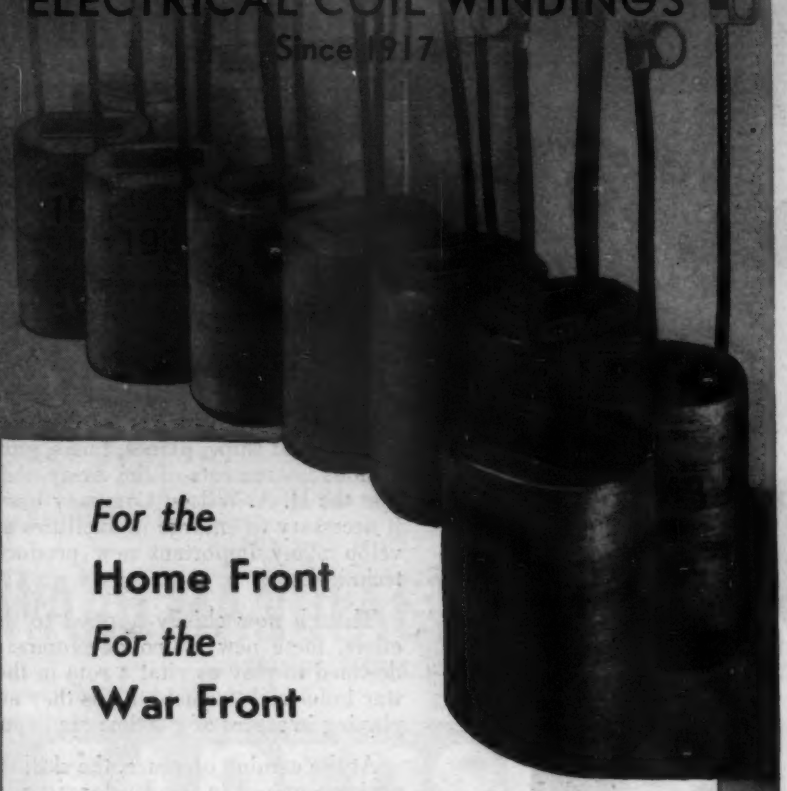
Thermometals—Electrical Contacts

Precious Metal Bimetallic Products

Coto-Coil

ELECTRICAL COIL WINDINGS

Since 1917



For the
Home Front
For the
War Front

DOWN thru the years COTO-COIL has pioneered in the manufacture of every type of coil winding.

All of this experience and skill acquired thru "doing" now are directed to the production of vital military equipment.

When *"C" Day comes we will be ready and waiting. May we help you NOW or THEN?

If you have a coil winding problem, phone, wire or write.

* "CONVERSION DAY"

COTO-COIL CO., INC.

65 PAVILION AVE. PROVIDENCE 5, R. I.

Two of thirty-three women engineers to finish a nine-month Westinghouse-sponsored course at Carnegie Institute of Technology. Evelyn Work and Betty Haynes determine the characteristics of an amplifier tube with a cathode-ray oscilloscope and a wave analyzer

these graduates are being placed in engineering and research laboratories of Westinghouse Elec. & Mfg. Co. plants in various eastern cities. The company sponsored the training program. During the course, the students had all expenses paid and, in addition, received $50 a month.

More Accurate Broadcast Data

BECAUSE MANY BROADCAST licensees have, in the past, been filing renewal applications with gross errors which are repeated time and time again, FCC has established two new forms which require that the chief engineer or technical director of a station swear or affirm the accuracy of contained information.

This step is to prevent the copying of data from previous renewal applications without reexamination by anyone having knowledge or information of the facts. One of the two forms applies to stations using non-directional antennas, while the other refers to those using directional types.

CAA Alaskan Radio

ALTHOUGH THE ARMY is operating most of the aircraft communication facilities in the Aleutians, Civil Aeronautics Administration operates three radio services throughout territorial Alaska.

Of the three, one provides communication with the actual aircraft in flight, another operates and maintains radio aids to navigation, and the third collects and dis-

YOU'VE SEEN THESE BEFORE

1919

1923

1934

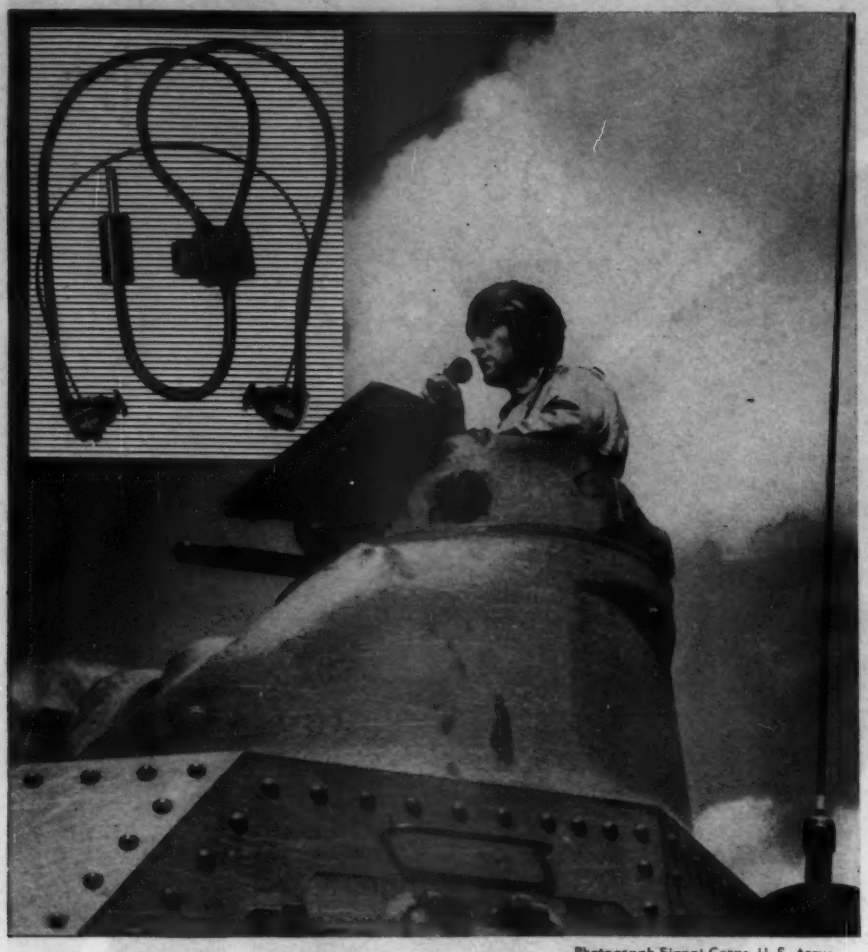
NOW

NO hasty development or Chinese copy of the units of some other manufacturer, the popular Types 214–314 Rheostats have been made by us for many years. The Type 214 was first brought out in its present general form in 1919. As materials improved . . . better wire . . . better insulation . . . more accurate winding methods . . . better mechanical design of molded form, winding cards and contact arms . . . the Type 214 gradually reached its present stage. They are being turned out just as quickly and in just as large volume as we are able. After the war we may have some radical improvements in our entire rheostat line. In the meantime when ordering rheostats that look like G-R, why not *buy* G-R, if our present delivery schedules meet your requirements.

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

NEW YORK CHICAGO LOS ANGELES



Photograph Signal Corps, U. S. Army

YOU'LL WANT TELEX RECEIVERS, TOO

WHETHER worn in the din of battle somewhere in France or in a library at home, Telex powerful, rugged, lightweight, magnetic receivers deliver dependable performance.

Magnetic receivers are now being made in large quantities according to U. S. Army Signal Corps specifications, by Telex, creators of the world's first wearable electronic hearing aid.

Telex experience in supplying these receivers to the Signal Corps should be of assistance to you in any plans you have for the creation of postwar sound transmission or communication devices requiring receivers. Write and tell us your problem.

Telex Experience Offers:

MAGNETIC RECEIVERS:

Cu. Vol.—Approx. 0.3 cu. in.

Impedance—Up to 5000 ohms.

Sensitivity—18 dynes/sq. cm. for 10 microwatt input.

Construction—Rugged, stable, using only finest materials, precisely machined—no diaphragm spacing washers in Telex receivers.

TRANSFORMERS AND CHOKES:

Cu. Vol.—Down to .15 cu. in.

Core Material—High permeability steel alloys.

Windings—To your specs. (Limit of six outside leads on smallest cores.)

TELEX ELECTRONIC PRODUCTS DIVISION
PRODUCTS COMPANY

TELEX PARK · MINNEAPOLIS · MINNESOTA

tributes meteorological information.

When the radio installation program was started in 1940, point-to-point ground communication was served by medium-high frequency, while ground to aircraft contact was maintained over the voice channel of the radio range where these services existed. More recently, communication facilities have been added with operations located in the low-frequency band.

Because of frequent unfavorable conditions of the ionosphere in northern latitudes, high frequency transmission is hampered. Thus, low-frequency facilities are more dependable, even though operating speed cannot be as high.

While the meteorological and point-to-point communication in continental United States has for some time depended on land lines and teletypewriter transmission, the vast distances and scarcity of civilization make it likely that Alaskan aircraft will depend on radio for some time to come.

Survey of FM Activities

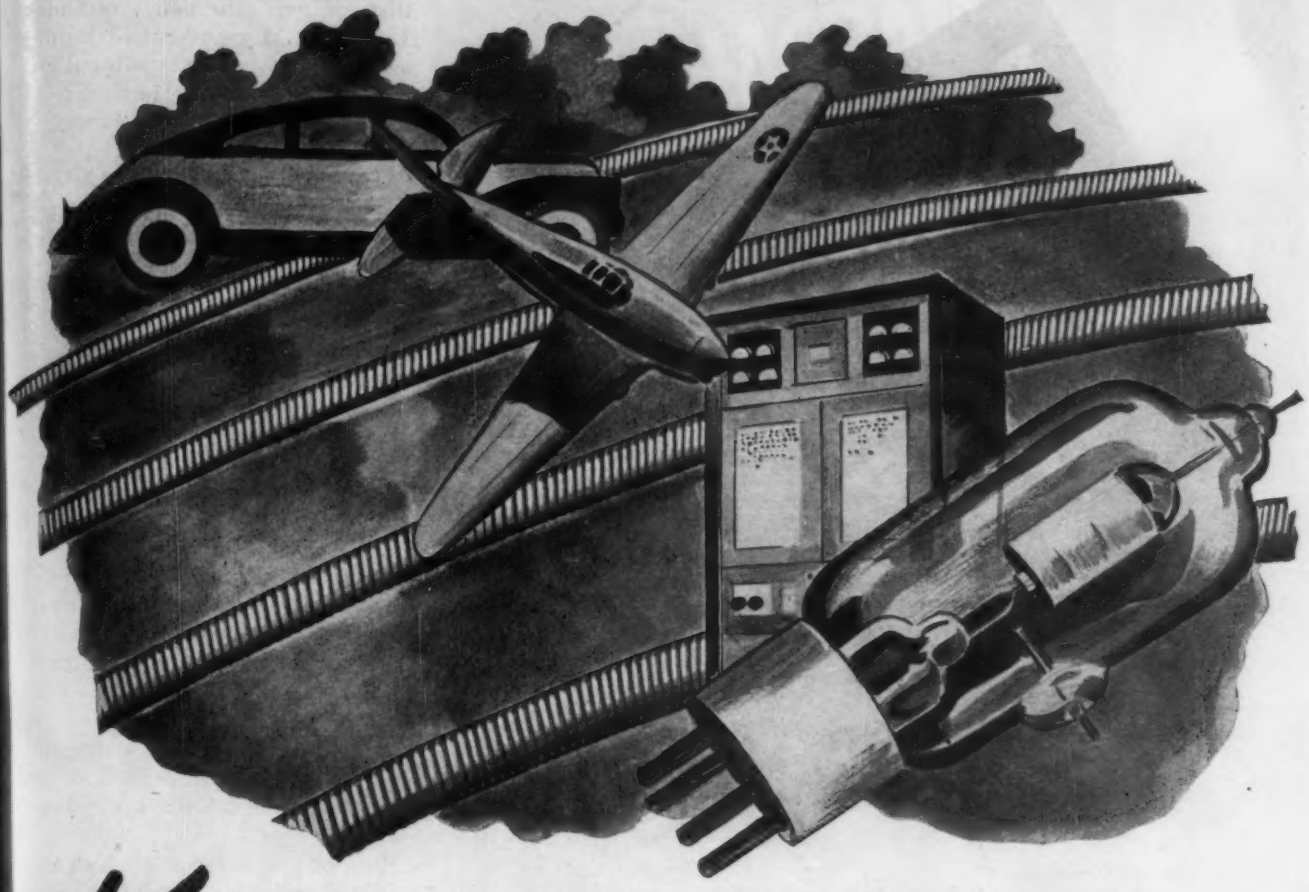
COMMENTS REGARDING the extent to which present and proposed policies of f-m broadcasters conform to the consideration of public interest, convenience, and necessity have been requested by FCC. A letter requesting such information has recently been dispatched to all national and regional networks.

Quoting from regulations, FCC points out that it is authorized to consider, in addition to the minimum technical requirements, the extent to which the station has made or will make use of its facilities to develop a distinct and separate service from that otherwise available in the service area.

Civilian Essentialities

IT IS ESTIMATED that 12,000,000 radio tubes above present production would be needed to put the civilian economy on a basis of unrestricted supplies. William Y. Elliott, vice chairman for civilian requirements has established three theoretical levels and supplied to WPB estimated figures for meeting each in a long list of commodities.

Level No. I is designated as mini-



Know THE RANGE AND SCOPE OF S.S.White Flexible Shafts

Because there are many places in electronic equipment where a *power drive* is needed for instruments or other auxiliaries, and many more that call for *remote control* of parts requiring operational adjustment, every engineer-designer should be familiar with the possibilities of S. S. White Flexible Shafts. For S. S. White shafts serve these two functions with the following decisive advantages.

1. **SIMPLICITY**—With a single, easily applied shaft you can transmit power or remote control around turns, past obstructions or through congested areas. This means fewer parts, simplified assembly, faster production, lower costs.

2. **BETTER DESIGNS**—Flexible shafts give you complete freedom in placing driving and driven or controlled elements wherever you want to put them to best satisfy circuit requirements, space conditions, ease of assembly, convenience of operation and servicing.

3. **ECONOMY**—In addition to the economy of simplicity, flexible shafts make accurate alignment of connected parts unnecessary, further reducing assembly costs.

FOR BASIC DATA on S. S. White Flexible Shafts for power drives and for remote control ask for Bulletin 43. Your copy mailed on request.

ARMY E NAVY

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

DEPT. E 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS AIRCRAFT ACCESSORIES
MOLDED PLASTICS
MOLDED RESISTORS FLEXIBLE SHAFT TOOLS

Covers resistance range of 1 ohm to 999,999 ohms.

★

Each decade dissipates up to 225 watts. Greenohms (wire-wound cement-coated power resistors) used throughout. Glass-insulated wiring.

★

Six decade switches on sloping panel.

★

Maximum current per decade: 5, 1.5, .5, .15, .05 and .005 amp.

★

Attractive frosted - gray metal case. Etched black-and - aluminum panel. Dual binding posts for left- and right-hand duty.

★

Grille at bottom and louvres at side for adequate ventilation. Baffle plate protects switch mechanism against internal heat.

★

13" long, 8½" deep, 5¾" high. Weight, 11 lbs.

★ **Since its introduction several years ago, the Clarostat Power Resistor Decade Box has become a "must" among busy engineers, laboratory workers, maintenance men and others. Especially so during the hustle and bustle of war work.**

Definitely in a class by itself. There's nothing else just like it. Note that it is a *power resistor* decade box. That means the introduction of the correct resistance value for any circuit or application, *for use under actual working conditions*, at the mere twist of the knobs. The resistance which provides the correct operating conditions is then read directly off the dials. No calculations required. No guesswork. No time-consuming routine. No wonder the Clarostat Power Resistor Decade Box pays for itself in short order.

★ **Write for literature . . .**

Descriptive bulletin sent on request. Likewise literature on controls or resistors in which you are particularly interested. Let us quote on your requirements.

CLAROSTAT

Controls and Resistors

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N.Y.

mum essential requirements, with distribution through rationing. Level No. II represents minimum essential requirements without control on distribution. Level No. III means an unrestricted supply of products.

Therefore, while the 4,500,000 vacuum tubes estimated to be produced in the third quarter of this year will fill the requirements of Level I, 10,000,000 would be needed for Level II and 16,500,000 for Level III. Farm radio batteries are estimated at 45,000,000 cells for the third quarter, while 91,200,000 would be required for Level II and 121,600,000 for Level III.

Training in Electronics

SPECIAL FREE COURSES in radio and electronics will start during August in major war production centers throughout the state of California. Offered by University of California, these classes are designed for full-time workers who are able to devote two hours a week to lectures and an equal amount to home study.

Training is offered at both elementary and advanced levels. Prerequisites are employment in a war industry plus high-school graduation or equivalent. To facilitate attendance, OPA regulations permit application for supplementary gasoline allowances.

Detailed information can be obtained from U of C war training centers in Berkeley, Los Angeles, or San Diego. Courses are part of the Engineering, Science, and Management War Training Program of the U.S. Office of Education.

Postwar Prognostications

SURVEYS OF POTENTIAL MARKETS for the months after the war are being made in large numbers by government agencies, commercial concerns, and publications. Sample findings:

Among the many appliances covered in a recent survey made by WPB, radios placed sixth in consumer demand. Out of 4,488 households interviewed, 154 would buy a radio first if such commodities were readily available, and 89 would buy radios second. Estimated on the same basis, U. S. totals for first and second pur-

A DECAL WIRING DIAGRAM IS ALWAYS THERE!

Meyercord Decal diagrams "stay put"! They are easy to apply, yet eliminate the danger present in easy-to-come-off paper and glue-type diagrams. They're engineered to "stand up and take it" under grueling tropical sun, in the frigid arctic, in humid jungle. Meyercord Decals are washable—complete immersion will not destroy their legibility or adhesion! They are durable, vibration-proof, and can be produced in any size, design, or colors.

Wiring diagrams... special Ordnance lubricating guides for combat vehicles... stowage charts, spare parts listings—these are but a few of the hundreds of ways in which Meyercord Decals are serving the armed forces. Used for nameplates, instructions, and insignia on vessels, tanks, planes, and other combat equipment, they save time, money, weight and metal. Send for complete literature. Address inquiries to Department 9-8.

Speed Victory-Buy War Bonds

MEYERCORD DECALS

The Meyercord Co... World's Largest Manufacturers of Decalcomania

5323 WEST LAKE STREET • CHICAGO (44) ILLINOIS

Revolutionary Hy-cycle Automatic Arc Provides Complete Control of Arc and Heat

At last, a development that automatically starts the arc before the welding electrode actually comes in contact with the work! Eliminating the "pecking" or "scratching" that so often creates tension and operator fatigue. Its many advantages contribute largely to saving time and labor because an operator can be trained in far less time than usual, and higher speeds can be obtained. This hy-cycle automatic arc unit, called "Missing Link," permits the operator to weld with any welding rod, bare steel or alloy. Rods that could not be used before can be burned with ease—such as bare mild steel, dust coated, reverse polarity, aluminum, bronze, stainless steel, etc., AC or DC.

One of its most important advantages is welding light gauge. Light gauge requires low heat—making many jobs almost impossible for ordinary methods. Since the "Missing Link" starts automatically on as low as one ampere of heat, the welding of light gauge sheet can be done with surprising speed with no time out for "pecking" and "sticking."

Simplifies welding vertical and overhead

Makes it easy to weld light gauge work

You all know that our fighting men need the finest quality materials that we here at home can produce. That goes for Wrigley's Spearmint Gum, too. Although our stock pile of quality raw materials is getting lower and lower we are maintaining our standards of quality. Naturally, we are forced to limit production. So we are giving priority where it is needed most—and where you want us to—our fighting men and women overseas only. Because chewing gum is essential to them—they are getting all of our limited production of Wrigley's Spearmint Gum.

You can get complete information from Mid-States Equipment Company, 2429 South Michigan Avenue, Chicago 16, Illinois.

Y-135

chases would amount to 2,030,508.

Ranking radios in potential popularity, and in order, were washing machines, electric irons, mechanical refrigerators, cooking stoves, and electric toasters.

Meanwhile another survey, run off by McCall's magazine, indicated a very striking preference for modern over traditional styles in radio cabinets. Questions asked of women in all parts of the country and from all age, income, and occupational groups were designed to indicate choices among console type radios, table models, radio-phonograph combinations, television sets, and pianos.

Depositors at the Franklin Square National Bank of Nassau County, Long Island, N. Y., have participated in a plan in which they make deposits earmarked for specific postwar purchases. Television receivers head the list. And if the figures of the bank are extended to a national average, there are 1,600,000 people in the country ready to utilize $652,000,000 for the same purpose. Funds of $400 are set aside by the depositors for this purpose.

Pent-up demand for radio receivers is estimated at a potential of 20,000,000 sets by J. H. Rasmussen, Crosley Corp., who recently addressed the Advertising and Sales Executive Club of Kansas City. He pointed out that the radio industry produced 13,000,000 receivers in its peak year and that during the current year it will produce about ten times the value of that year's output.

Surplus Electronic Goods

BESIDES BASIC COMPONENT PARTS like bolts, nuts, screws, rivets, and the like, the Surplus War Property Division of U. S. Treasury Procurement is doing business in such surplus war properties as radio tubes, professional and scientific instruments and apparatus, coin operated machines, radio broadcast receivers, and battery charging generators.

To keep posted on merchandise available, write to the nearest regional office and ask to be put on the appropriate mailing list. Requests should be accompanied by a statement of the specific merchandise lines normally manufactured

Built to take it . . . *anywhere* . . . *anytime!*

● ● ● ● Techrad LRR-4 is built to take it under any and all conditions. This Techrad receiver has F.C.C. approval for low radiation, but there are many more reasons why it is winning such general acceptance.

Techrad LRR-4 is built to insure uninterrupted performance under the most drastic conditions of service . . . *anywhere in the world.* Because of its massive and rugged construction, it can be counted on to get there, and to get there intact. It will stand transshipment on the bang-slam carriers found in remote places and be ready to go into service upon arrival at its destination.

TECHRAD

Techrad LRR-4 will work in any climate. It offers a high degree of resistance to tropical humidity and to tropical organisms because *LRR-4 transformers are hermetically sealed* . . . and *LRR-4 wiring and terminal boards are completely Anti-Fungus treated.* It will also stand up under severe duty at sea, because *LRR-4 is capable of withstanding the Salt Spray Test.* Techrad LRR-4 is available in a number of different models which cover a variety of frequency ranges.

● ● ● ●

MASTER ENGINEERING TAKES NOTHING FOR GRANTED.

Technical Radio Company

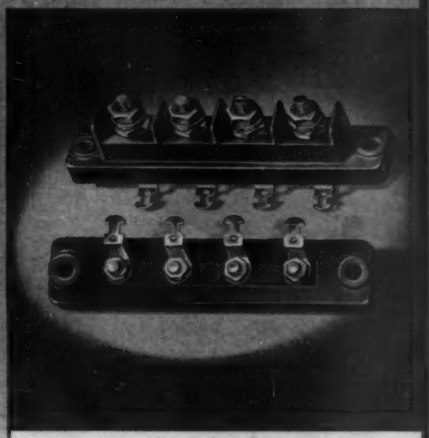
Over ten years of continuous experience

275 Ninth Street · San Francisco 3, California

Export Agents: Frazar & Hansen, 301 Clay St., San Francisco 11, California, U. S. A.

Designed for

Application



The No. 37104 Terminal Strip

is a sturdy four-terminal strip of molded black General Electric Textolite much used on present production Army and Navy equipment. Barriers between contacts. "Non turning" studs, threaded 8/32 each end.

JAMES MILLEN MFG. CO., INC.

MAIN OFFICE AND FACTORY

MALDEN, MASSACHUSETTS

or bought for resale. Regional offices are located in Boston, Washington, Chicago, Atlanta, Kansas City, Seattle, New York, Cincinnati, Denver, Fort Worth and San Francisco. Capital and producer's goods are being distributed by Reconstruction Finance Corp.

Brazilian Radiophone Network

THE CAPITALS of all states and territories of Brazil will be linked together into one comprehensive radiotelephone network, under the terms of a decree recently issued by President Getulio Vargas.

Existing internal radio and wire lines are to be supplemented by new equipment built and operated by a subsidiary of International Telephone & Telegraph Corp.

Since Brazil has no connections between the central sections of the country around Rio de Janeiro, Sao Paulo, and Santos by land-wire telephone to the south, north, and west areas of the Republic, the new facilities will fill a long-felt need.

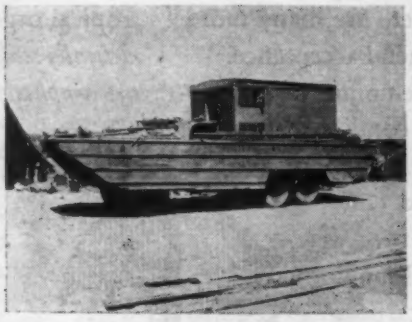
Communication in the Navy

MORSE CODE is featured heavily in the communication procedures of our Navy according to comment made by Rear Admiral Joseph R. Redman, Director of Naval Communications, during recent ceremonies marking the anniversary of the telegraph.

He pointed out that it is not even

• • •

ON THE AIR FROM A DUCK



Launched from an LST at Anzio beachhead, a duck similar to this bore the first radio station to speak to the American public from a front line position. It was designated by the call JJRP and soon became known as Jig Jig Roger Peter to the Army. The transmitter used was an SCR-299, made for the Signal Corps by Hallicrafters Co., Chicago, Ill.

TO THE POINT

We May Have The Answer To Your Post-War Need For Electronic Controls or Assemblies

If you have a post-war production problem involving electronic devices or sub-assemblies in quantity, our broad experience in the design and manufacture of electronic equipment may offer the best answer. Your inquiry will put you under no obligation.

Among our present products are

• Electronic Sound Devices • Intercommunicating Systems • Industrial Voice-Paging and Broadcasting Equipment • Permanent and Portable Amplifying Systems • Recording and Disc-Playing Units • Electronic Controls • Operating Sequence Recorders • Other Special Electronic Devices.

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SHOWS A WIDE BAND OF FREQUENCIES ALL AT ONCE

Panoramic reception is defined as the SIMULTANEOUS VISUAL reception of a multiplicity of radio signals over a broad band of frequencies. It is a technique that literally allows you to see what you are missing. In ***communications,*** for example, while ordinarily only one station may be received at one time, with Panoramic reception, the presence and characteristics — signal strength, frequency stability, modulation, etc. — of a number of stations may be seen concurrently.

In other applications, as well, Panoramic reception permits you to see what you're missing. In ***direction finding,*** signals too weak to give an aural indication can be made to give a satisfactory bearing with its use. In ***transmission,*** field strength and frequency of transmitter can be accurately compared with a standard signal. And in ***production,*** Panoramic reception may be utilized to compare components with a standard.

Why not let one of our engineers explain to you the principle of Panoramic technique, and how it may be used to your advantage.

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possible to maintain peacetime speed of transmission since the weakest link in the chain must be considered. Also, since radio silence may be in effect, a repeat or verification cannot be requested. Therefore, transmission goes on at a rate of about fifteen words a minute.

Certain unspoken agreements exist within radio communication. Although, as he pointed out, effective jamming methods for enemy transmissions have been developed, very little of it has been done because of the fear of retaliatory tactics. Frequency assignments are still registered with the Berne Bureau, and not long ago our State Department received via that organization an objection to some proposed frequency restriction from the German Government.

BUSINESS NEWS

Federal Telephone & Radio Corp. converts 3000 sq ft of space at 333 North Michigan Ave., Chicago, Ill. to the purposes of its midwestern activities.

Name of radio and electronic equipment making **Phil-American Inc.**, New York, N. Y., is changed to **Philharmonic Radio Corp.** New location is 528 East 72 St., New York 21, N. Y.

In Chicago, Ill., a new company is formed as **Electronic Mfg. Co.** to make transformers, chokes, and wave filters, besides providing consultation on apparatus design.

Colonial Radio Corp. Buffalo, N. Y. becomes a wholly-owned subsidiary of **Sylvania Electric Products Inc.** by purchase of capital stock. No personnel changes are involved.

Partial ownership of **Progressive Welder Co.**, Detroit, Mich., is transferred to the employees through a stock purchase and ownership sharing program.

At **Machlett Laboratories,** whose first radio transmitter tubes were recently put into service in NBC broadcasts to Europe, free electronics courses are offered to all employees both in Springdale and Norwalk, Conn., location of the company's two plants.

To meet increased war production demands, **United States Rubber Co.** is establishing new manufac-

IN EVERY NEEDED SIZE --

for Every Needed Purpose!

BL
METALLIC RECTIFIERS

B-L SELENIUM RECTIFIER PLATES are made in diameters from ¾ inch to 4⅜ inches. B-L Copper Sulphide Junctions are made from ½ inch to 1¾ inch.

We assemble these elements into stacks of varying sizes, to do innumerable power-conversion jobs. Typical applications of B-L Metallic Rectifiers range all the way from tiny stacks for sensitive control devices to huge assemblies for giant industrial power units.

No matter what rectifier applications you are considering, B-L will be glad to work with you. Selenium and Copper Sulphide Rectifiers for all needs are available.

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BL

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Designers & manufacturers of Copper Sulphide & Selenium Rectifiers, Battery Chargers, and D. C. Power Supplies for practically every requirement.

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The finest name for the finest wire

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FINE WIRES

turing facilities in a number of eastern and midwestern states. Among them are Signal Corps wire operations at Lowell, Mass.

Grayhill is the brief name of a new company organized in Chicago, Ill., with general offices at 1 North Pulaski Road and manufacturing establishment in La Grange, Ill. Products are to include mechanical and electrical switching devices.

In Boston, Mass., **General Control Co.** removes to a new office and plant at 1200 Soldiers Field Road. Facilities, which occupy several times the space available at the

previous location, include an enlarged engineering department, new laboratory equipment for the development and testing of electrical and electronic products, and an assembly hall for engineering meetings.

Radio station KEX, Portland, Ore., is sold, subject to FCC approval, by the *Portland Oregonian* to **Westinghouse Radio Stations Inc.** Price was $400,000.

Raytheon Production Corp. changes its name to the Radio Receiving Tube Div., **Raytheon Mfg. Co.**

With the formation of a subsidiary company, **RKO Television Corp.**, **Radio-Keith-Orpheum Corp.** relates its production and programming facilities to video.

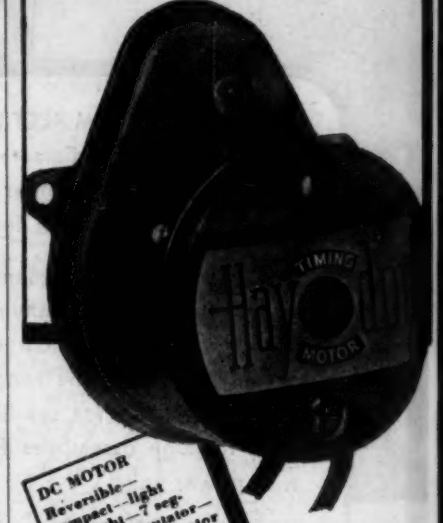
Carbonyl iron powder, used in the making of cores for inductive devices, is being made in this country by **General Aniline & Film Corp.**, New York, N. Y. The company, seized from German ownership, is supplying the entire demand for the material which was formerly imported from Germany. Other products include Polectron resins used in the manufacture of paper capacitors.

Addition of twelve RMA members results in a peak record of 210. New affiliates are **Consolidated**

AC TIMING MOTOR
Available 450 RPM (or faster) to 1 REV. per month; manufactured to your specific voltage, frequency, speed and torque requirements.

TIME IS PRECIOUS—
PLAN TODAY FOR
TOMORROW

Timing is vital today—indispensable tomorrow!
Compact, rugged and with extreme flexibility, Haydon timing motors lead the field. Manufactured to your specific voltage, frequency, speed and torque requirements, they are available with brake for instant stop — reversible, and with shift device for automatic reset.
Whatever Your Timing Problems May Be... our timing engineers are ready and willing to help you solve them — Just drop a line to our Timing Engineering Service Department.



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Reversible—compact—light in weight—7 segment commutator—low reactance rotor winding—alnico field—totally enclosed.

As makers of the most complete line of Synchronous Timing Motors, Haydon Manufacturing Company offers a complete TIMING ENGINEERING SERVICE

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18" x 9" x 9"

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24 STOCK SIZES

As per specification 42 B 9 (Int) for shipboard use, Electrical and Mechanical. Navy grey finish. Immediate Delivery.

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Number	Length	Width	Height	Number	Length	Width	Height
1025- 1	12	6	6	1025-13	18	18	12
1025- 2	12	9	6	1025-15	24	15	12
1025- 3	12	12	6	1025-16	24	15	15
1025- 4	12	9	9	1025-17	24	18	12
1025- 5	18	9	6	1025-18	24	18	15
1025- 6	18	9	9	1025-19	24	18	18
1025- 7	18	12	9	1025-20	24	12	9
1025- 8	18	6	6	1025-23	30	15	9
1025- 9	18	15	9	1025-14	30	15	12
1025-10	18	12	6	1025-22	36	12	9
1025-11	18	15	12	1025-21	42	9	9
1025-12	18	12	12	1025-24	42	12	9

No. 1025—14
30" x 15" x 12"
(Partitions not included)

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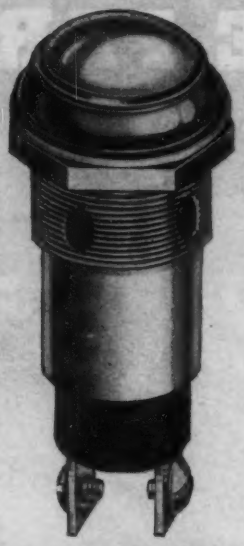
NEW Gothard
NAVY SPEC. BAKELITE BASE
PILOT LIGHT

for 110 volt operation



This new light, with 1" jewel, is available in three models; No. 1032 faceted jewel; No. 1033 plain jewel and No. 1034 frosted jewel, colored disc. Sockets are molded of bakelite to meet Navy specifications, 17P4-CFG. Removable jewel holder, of snap-in type, permits change of lamp from front of panel. 3/8" between terminals. Designed for Mazda 6S6 lamps. Selection of jewel colors; red, green, amber, blue, opal and clear—specify choice when ordering.

Gothard

Ask for the new Gothard Catalog of other models.

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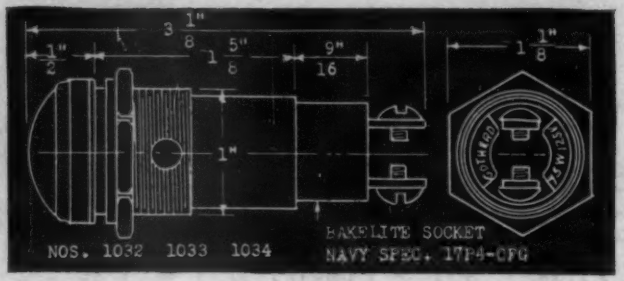
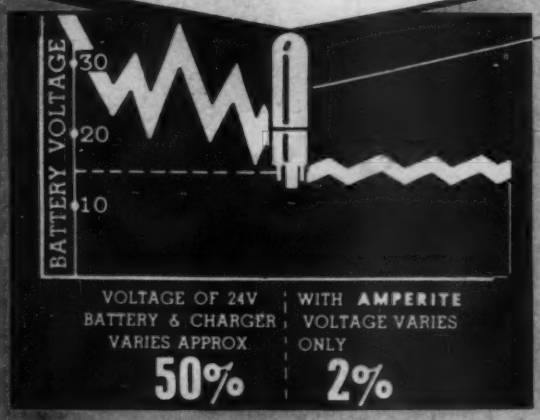


ENGINEERS: Here's the BIG POINT about
AMPERITE REGULATORS



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Features:

1. Amperites cut battery voltage fluctuation from approximately 50% to 2%.
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3. Compact . . . light . . . and inexpensive.

Used by U.S. Army, Navy, and Air Corps.

DELAY RELAYS: *For delays from 1 to 100 seconds. Hermetically sealed. Unaffected by altitude. . . . Send for catalogue sheet.*

NEW! 4-page folder will help you solve Current and Voltage Problems; contains much valuable data in practical form — *Write for your copy now.*

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Radio Products Co., Chicago, Ill.; **Crystal Research Laboratories**, Hartford, Conn.; **Electronic Laboratories**, Indianapolis, Ind.; **Electronic Engineering Co.**, Chicago, Ill.; **Electronic Tube Corp.**, Philadelphia, Pa.; **General Electronics Inc.**, New York, N. Y.; **Selenium Corp. of America**, Los Angeles, Calif.; **M. Simons & Son Co.**, New York, N. Y.; **Mark Simpson Mfg. Co.**, New York, N. Y.; **Universal Microphone Co.**, Inglewood, Calif.; **Viewtone Co.**, New York, N. Y.; and **Winters & Crampton Corp.**, Grandville, Mich.

PERSONNEL

At Summit, N. J., **F. H. Shepard Jr.** opens his new office and laboratory for consultation on such electronic specialties as industrial control, servo mechanisms, special amplifiers, and photoelectric applications.

Permoflux Corp., Chicago, Ill., gives responsibility for development on acoustic transducers to new chief engineer, **Raymond C. Bierman**, former studio field engineer with NBC.

Louis Dolinko joins the engineering staff of United Electronics Co., Newark, N. J. He has been an instructor in radio engineering at Scott Field, Ill.

In Brooklyn, N. Y. Amperex Electronic Products adds to its engineering staff **John F. Dryer Jr.**, previously chief of the electrical research department, Duramold Div., Fairchild Engine & Airplane Corp.

The Rochester, N. Y., section of AIEE elects to chairmanship **Oliver L. Angevine**, radio-telephony engineer of Stromberg-Carlson Co. Manager of research and engineering at the same company, **Dr. George R. Town** becomes treasurer of the section.

Caxton Brown succeeds **Edward F. Weston** to the presidency of Weston Electrical Instrument Co., Newark, N. J. Mr. Weston becomes chairman of the board.

In the electronic apparatus section of RCA Victor Div., Radio Corp. of America, Camden, N. J., **Walter L. Tesch** becomes application engineer while **Thomas F.**

Battle Talk

is our business!

Every move our fighters make on land, at sea or in the air is based on communications. Men depend not only for their orders but for their very lives on radio and telephone and many other communications devices. In every battle, on every front including the home front, you'll find apparatus made by Western Electric—the nation's largest producer of electronic and communications equipment for war.

Buy all the War Bonds you can—and keep all the War Bonds you buy!

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Western Electric

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RECORDING STUDIOS!
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You Can Get Them
Without Delay!

GOULD-MOODY
"Black Seal"
GLASS BASE INSTANTANEOUS RECORDING BLANKS

The tributes paid to "Black Seal" discs by many leading engineers have been earned by distinguished service on the turntable. Your ears will recognize the difference in quality of reproduction, and the longer play-back life will prove the superiority of "Black Seal" construction. Choice of two weights — thin, flexible, interchangeable with aluminum, or medium weight — both with four holes.

An AA-2X rating is automatically available to broadcasting stations, recording studios and schools. Enclosure of your priority rating will facilitate delivery

Old Aluminum Blanks Recoated with "Black Seal" Formula on Short Notice

THE GOULD-MOODY COMPANY

RECORDING BLANK DIVISION
395 BROADWAY · NEW YORK 13, N. Y.

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89 BROAD STREET, N. Y.

Kenna becomes commercial engineer on high-frequency induction heating equipment. Mr. Tesch has been manager of the record engineering department. Mr. Kenna comes from Van Norman Machine Tool Co.

At Lord Mfg. Co., Erie, Pa., **Leon Wallerstein Jr.** advances to development engineer in charge of the development laboratory. **Paul C. Roche** becomes chief field engineer and **R. C. Henshaw** takes over the function of chief engineer.

E. J. Rehfeldt (above) is manager of planning and production, and **Harry Holubow** (below) chief engineer of Electronic Mfg. Co., Chicago, Ill. Both have been with Thordarson Electrical Mfg. Co.

Electrical Papers

ARE INCLUDED IN THIS *NEW* BOOKLET NOW AVAILABLE

This colorful new book tells how paper is being employed to improve products, lower costs and increase production. It explains what Electrical Papers and other Industrial Papers are, how their physical properties can be controlled to fit an amazing variety of purposes, and contains a list of 68 Industrial Papers, their characteristics and uses in industry.

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This book may contain the solution to your production problem of today or tomorrow.

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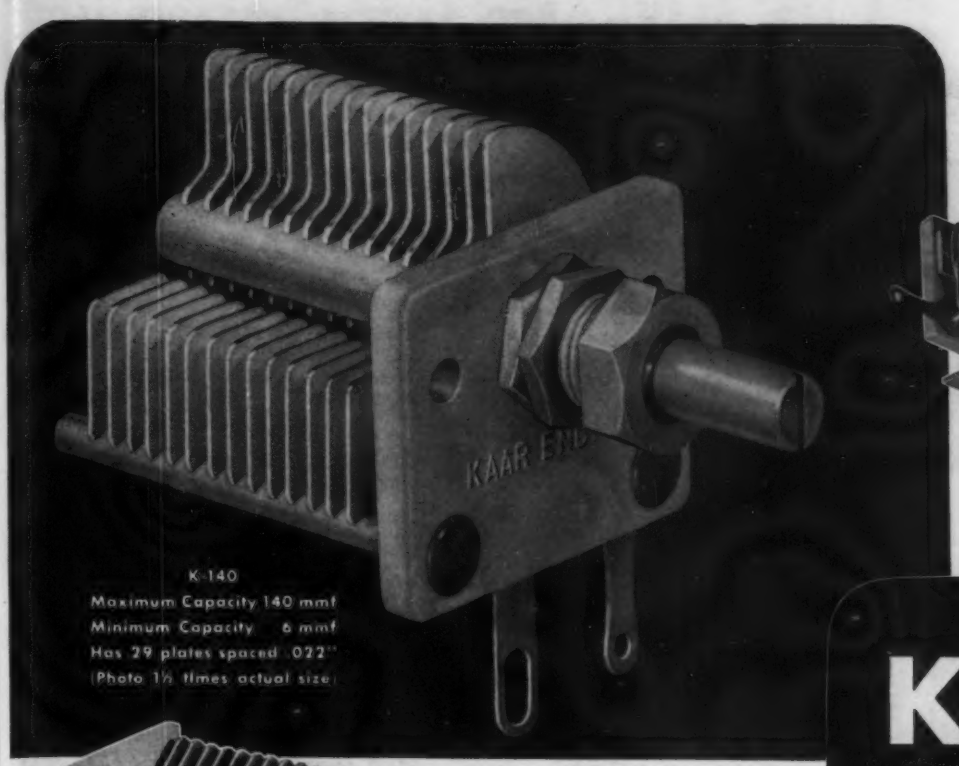
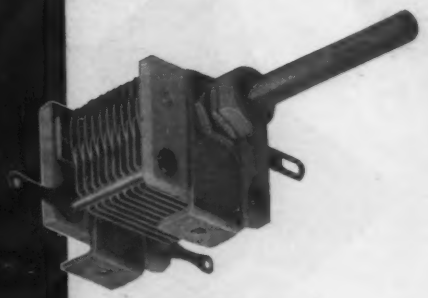
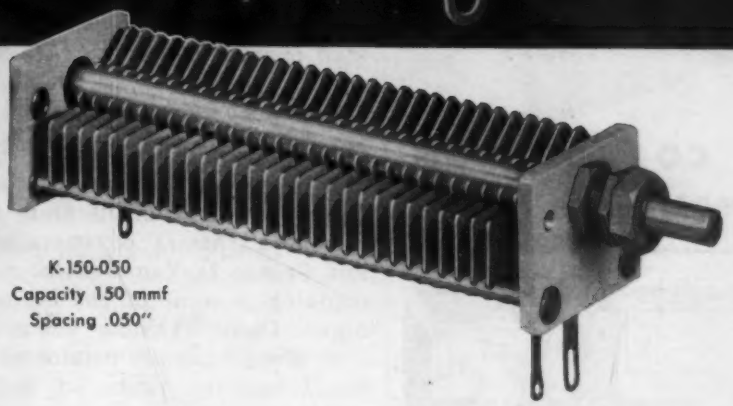


K-140
Maximum Capacity 140 mmf
Minimum Capacity 6 mmf
Has 29 plates spaced .022"
(Photo 1½ times actual size)



K-100-2B
Capacity 100 mmf
Spacing .022"



K-150-050
Capacity 150 mmf
Spacing .050"

KAAR
VARIABLE AIR CONDENSERS
FOR TANK CIRCUIT AND ANTENNA TUNING

Use this reliable West Coast source for Variable Air Condensers

Kaar Engineering Company now offers prompt delivery of standard and special types of variable air condensers suitable for many applications in radio transmitters and receivers. They are particularly useful as tank and antenna tuning capacitors in low and medium power transmitters.

The small cross-section of Kaar condensers allows a number of them to be assembled in multi-channel radio equipment in a minimum amount of space. Every Kaar capacitor is substantially constructed with soldered and plated brass rotor and stator plates. Shafts can be furnished slotted for screwdriver adjustment, and tapered lock nuts and split bushings assure positive locking without disturbing the adjustment.

Special types are available with very wide air gaps, double rotors and stators, high maximum capacities or special mounting brackets. Further information will be gladly furnished upon request.

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PALO ALTO, CALIFORNIA

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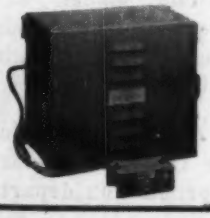
MOBILE RECEIVERS — Crystal controlled superheterodynes for medium and high frequencies. Easy to service.



CRYSTALS — Low-drift quartz plates. Fundamental and harmonic types available in various holders.

TRANSMITTERS — Mobile, marine, and central station transmitters for medium and high frequencies. Instant heating, quickly serviced.

MICROPHONES — Type 4-C single button carbon. Superb voice quality, high output, moisture-resistant.

POWER PACKS — Heavy duty vibrators and power supplies for transmitters, receivers. 6, 12, 32 volts DC.

This
I-F TRANSFORMER
is a Star
Performer

Here is a small (pictured actual size), permeability-tuned, precision-built I-F Transformer that is performing brilliantly in a number of important war applications. Now available for more general use, you may be able to use it to good advantage on some of your present or projected components. In any event, you should have the complete story on this simple, precise transformer in your files.

For complete information, specifications, quotations and delivery estimates on this LS-1 Transformer, write

CAMBRIDGE *Thermionic* CORPORATION
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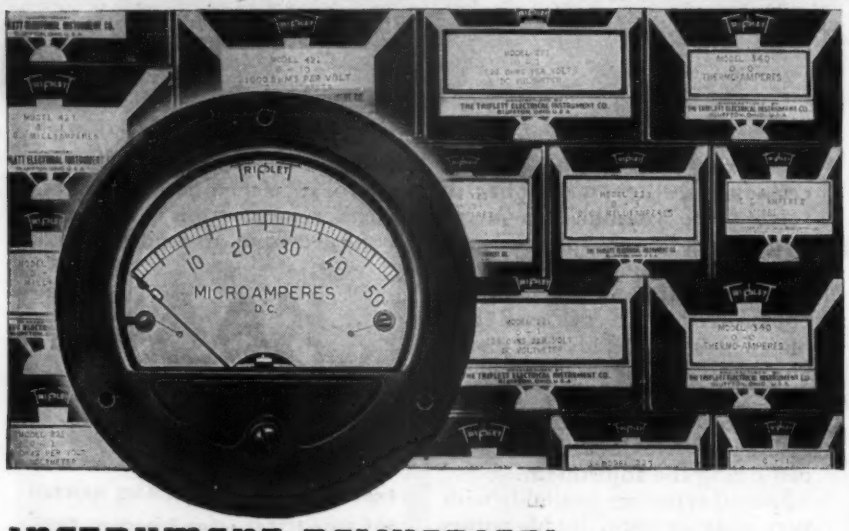

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- D'Arsonval Moving Coil D.C Instruments
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- Electrodynamometer A.C.-D.C.
- R.F. and Rectifier Types, Sizes 2" through 7"

STANDARDS ARE SET BY TRIPLETT

TRIPLETT ELECTRICAL INSTRUMENT CO.
BLUFFTON • OHIO

Walter T. Hopewell joins Lavoie Laboratories, Morganville, N. J. as general manager. He has been with ANEPA, and before that, U. S. Rubber Co.

At Eutectic Welding Alloys Co., New York, N. Y., **Clinton E. Swift** joins the organization as assistant manager in the engineering and research department.

New manager of the switchgear and control division, Westinghouse Electric & Mfg. Co., is **J. B. MacNeill,** former manager of switchgear engineering. He succeeds **R. A. Neal,** now vice president.

From the Montana School of Mines, where he has been professor of physics, Dr. **Daniel Q. Posin** goes to the Radiation Laboratory of Massachusetts Institute of Technology as a physicist and staff member concerned with war project research on high-frequency techniques.

Within the Signal Corps, Brigadier Generals **William S. Rumbough,** chief signal officer in the European theater of operations, and **George L. Van Deusen,** commanding general of the Eastern Signal Corps Training Center at Fort Monmouth, are nominated to the temporary ranks of major general.

In Bridgeport, Conn., **H. R. Kreutter** becomes acting supervisor of the technical service section, receiver division, General Electric Co. He has been serving as a design engineer of military equipment. Another appointment makes **C. G. Fick** receiver engineer responsible, among other activities, for production.

L. R. Thomas, system telegraph engineer of the Atcheson, Topeka, and Santa Fe Railway, is appointed electronics engineer.

Succeeding Captain **Maurice Edwin Curtis,** Captain **William Bronley Ammon** assumes the post of communications officer at the headquarters of Commander-in-Chief of the U. S. Fleet, Admiral **Ernest J. King.**

Frederick A. O'Leary becomes chief of the radio and radar section of the production department

NINE SEALED METAL-CLAD MICRO SWITCHES

used by REHNBERG-JACOBSON MANUFACTURING COMPANY to control operation of this automatic drilling and reaming machine

Rehnberg-Jacobson Company of Rockford, Illinois, use nine sealed metal-clad Micro Switches at strategic points to control the operation of their Automatic Drilling and Reaming Machine. This machine drills and reams 20 holes in sequence in the reduction gear pinion carrier for an aircraft engine. The Type RN Micro Switches used are sealed against the entrance of oil, dirt, and chips.

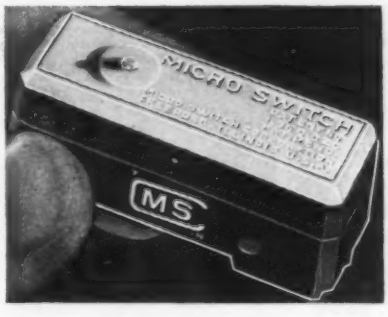
The piece is held in a fixture mounted on a standard Rehnberg 20" automatic index unit which is controlled by an 11-step program wheel. On the first step, the reamers rest; on the last step, the drills rest. There are four horizontally-mounted heads, two for drills and two for reamers, paired alike to drill two holes and ream two holes simultaneously.

The five metal-clad Micro Switches, shown on the front of the machine, control the electrical circuit. The two innermost switches of the left hand group control the program of the drilling and reaming units. The third switch of the group, directly in front, terminates the machine cycle after all drilling and reaming operations have been completed. The lower right hand switch stops the automatic index motor after each index cycle is completed. The upper right hand switch permits the machine cycle to be started only at the proper position of the indexed table.

The four Micro Switches mounted above each of the four units of the machine electrically interlock the machine in such a way that should either the drills or the reamers fail to retract from the work, the automatic index table will not index and break the tools.

Rehnberg-Jacobson Company's use of Micro Switches for this important operation is typical of the many uses which design engineers are finding for this tiny, accurate, snap-action electric switch. They find that, more than any other, it meets modern needs for a switch to control substantial amounts of power yet operate in small space.

Thousands of special housings, actuators and electrical characteristics... more than 2700... are available to meet almost every design problem. Send for Micro Switch Handbook-Catalog No. 60 today for full particulars. If your design is for aircraft, send for Handbook-Catalog No. 70 also.



The basic Micro Switch is a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, Underwriters' listed and rated at 1200 V.A. at 125 to 460 volts a-c. Capacity on d-c depends on load characteristics. Accurate repeat performance is experienced over millions of operations. Wide variety of basic switches and actuators meets requirements varying from high vibration resistance to sensitivity of operating force and motion as low as 2/1000 ounce-inches. Many types of metal housings are available.

"Uses Unlimited"—a dramatic talking motion picture of Micro Switches, in color, is available to industrial groups, training classes, schools and colleges, through Y.M.C.A. Motion Picture Bureau, New York, Chicago, San Francisco. Size: 16 mm. Length: 40 minutes. Write us for details.

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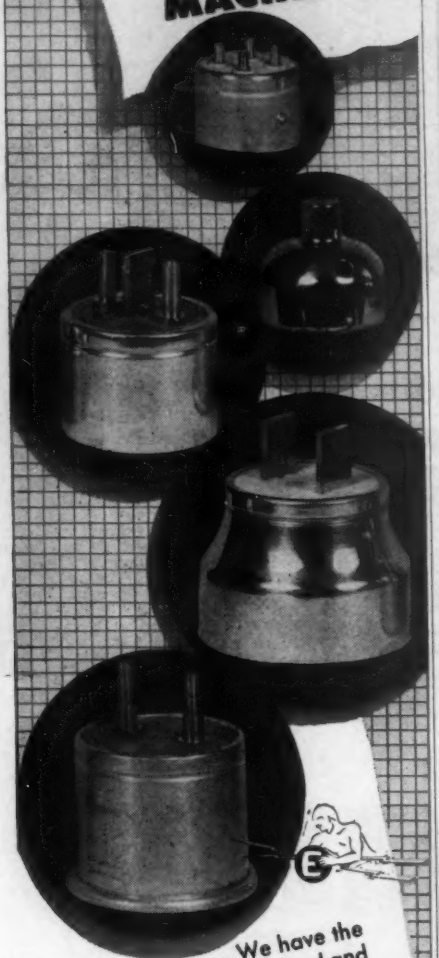
Vacuum Tube
MACHINERY



We have the engineering background and modern production facilities for the precision manufacture of Electronic Tube Bases, Caps, Tungsten Leads and Glass Working Lathes up to 6" for transmitting tubes. Consult our Engineering Department on your "special design" problems.

ELECTRONIC MANUFACTURING COMPANY
20 ORANGE STREET
NEWARK 2, N. J.

in the regional office of WPB, Boston, Mass. He was previously assistant chief and formerly with Raytheon Mfg. Co.

Andrew Co., Chicago, Ill., puts **Walter F. Kean** in charge of a new division which will supply field engineering and allocation service

to a-m and f-m broadcasters. Mr. Kean has been in charge of testing on radio and radar projects for Western Electric Co.

Within RMA, **Raymond C. Cosgrove,** vice president and general manager of Crosley Corp., becomes president to succeed **Paul V. Galvin.** Expansion of the board of directors from 27 to 34 involves the election of **Herbert A. Bell** of

Raymond C. Cosgrove, right, receives the gavel from retiring RMA president, Paul V. Galvin

SPINTITES ARE REAL SPEED UP TOOLS. This is the WRENCH that works like a SCREW DRIVER

Standard sizes for Hexagon nuts or headed screws . . . special SPINTITES for square or knurled nuts. Handles are either fixed or chuck type SPEED-UP design by makers of WALDEN WORCESTER WRENCHES

STEVENS WALDEN, INC.
459 SHREWSBURY STREET
WORCESTER, MASSACHUSETTS

DIRT—

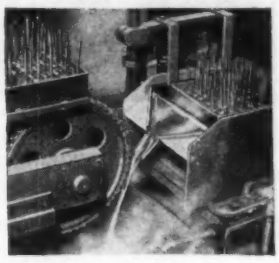
INSIDE ELECTRONIC TUBES CAN CAUSE TROUBLE TOO

Foreign matter within an Electronic Tube was always a hazard. Now, with the tendency toward miniature tubes and smaller parts with less distances between them, even a tiny thread of lint free in the glass enclosure can prove very damaging.

The TUNG-SOL regular procedure of washing and baking all mounts and glass enclosures just before sealing has proven a more than worth while precaution. It not only removes all dirt and dust and lint from component parts but at the same time removes any deposit of harmful salts that might poison the emission of electrons from the filament.

This final cleaning is just one of the innumerable practices instituted by TUNG-SOL research and development engineers, who have given TUNG-SOL Electronic Tubes their ruggedness, long life, efficiency and uniformity. These characteristics are important to both manufacturers and users of electronic devices. These engineers are available to you to assist in the designing of circuits and in the selection of the tubes that will do your job most efficiently.

EVERY DAY IS WASH DAY . . .



A continuous flow of hot water is introduced through the bottom of the washing tank and is discharged out the top floating the lint and foreign matter out with it. This prevents contamination of water. After washing, both mounts and enclosures travel through a high temperature oven, thoroughly clean and ready for exhaust.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

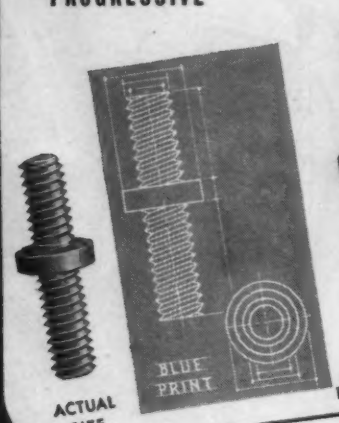
ARMY E NAVY

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERMITTORS

ANOTHER SPECIAL BY PROGRESSIVE

QUALITY PROMCO BRAND



ACTUAL SIZE

ENLARGED FOR DETAIL

71 other "specials" are illustrated in Catalog 18, which includes tables of weights per 1M standard pieces, dec. equivs. of fractions, etc. Write for it.

Special heads, threads, and finishes — on fastenings of any metal or alloy adapted to cold-upset — are Progressive's specialty. Weekly output: 25,000,000.

The PROGRESSIVE MFG. CO.
50 NORWOOD ST. TORRINGTON, CONN.

★ BONDS BUY MORE WAR BONDS ★

PRODUCTION
PRECISION
PROTECTION

Automatic Reset Time Delay Timer

HERE in one Timer are combined all the uses learned on the production fronts of industries engaged in war work. The Automatic Reset Time Delay Timer is designed for application on alternating circuits where an adjustable or fixed time delay between the closing of a circuit and the predetermined closing or opening of another circuit is required.

Some Typical Uses

- Control of heat applications
- Conveyors
- X-RAY Timing
- Closing plate circuits (electronic devices)
- Time sequence control for timers in multiple.

Write for bulletin A 12 for complete information and prices

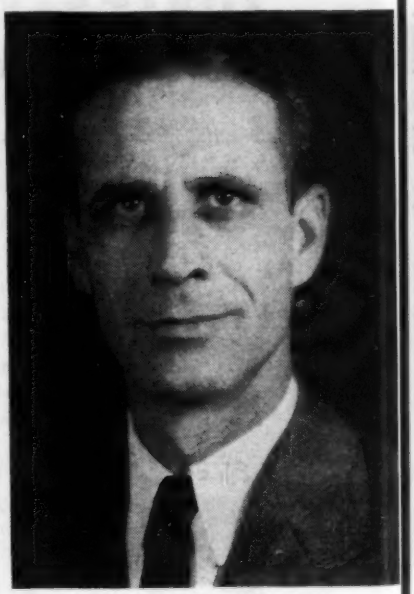
INDUSTRIAL TIMER CORPORATION
110 EDISON PLACE NEWARK, NEW JERSEY

Packard-Bell Co., **Joseph Gerl** of Sonora Radio & Television Corp. (set division), **Fred R. Lack** of Western Electric Co., **George Lewis** of Federal Telephone & Radio Corp. (transmitter division), **Ernest Searing** of International Resistance Co., **S. I. Cole** of Aerovox Corp., and **Monte Cohen** of F. W. Sickles Co., (parts division). **Frank M. Folsom** of RCA Victor Div. was elected to succeed Dr. **C. B. Jolliffe; R. E. Carlson** of Tung-Sol Lamp Works, to succeed **Roy Burlew;** and **G. Richard Fryling** of Erie Resistor Corp., to succeed **George R. Blackburn.**

At WABD, DuMont Television station in New York, N. Y., **Sal Patremio** advances from operating engineer to acting chief.

As an application engineer, **A. H. Krüger** joins Wheelco Instruments Co., Chicago, Ill. He has been identified with industrial heating and processing for a number of years.

Dr. Ellis R. Ott, recently associate professor of mathematics at the University of Buffalo, becomes executive engineer and assistant to



the director of engineering at National Union Radio Corp. His headquarters will be at the research and development laboratories, Newark, N. J.

—◇—

ABOUT 25 PERCENT of the prewar personnel of broadcasting stations and networks are in uniform.

The HARVEY Regulated Power Supply 106 P A

You'll find it ideal for operation with pulse generators, measurement equipment, constant frequency applicators, amplifiers and any other equipment requiring a constant flow of D. C. voltage.

Designed to operate from 115 volts A. C., the HARVEY 106 P A has a D. C. voltage output variable from between 200 to 300 volts and accurately controllable *to within one per cent.* A model of efficiency and convenience, it has separate fuses on each transformer primary as well as the D. C. output circuit: pilot lights on each switch; a D. C. voltmeter for measuring output voltage and a handy two-prong plug or binding posts to permit easy hook-up.

For complete information on this precision-built, thoroughly dependable source of constant voltage, write for the new HARVEY Regulated Power Supply bulletin. Address your requests for this useful new bulletin to

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HARVEY RADIO LABORATORIES, INC.
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HARVEY OF CAMBRIDGE ANNOUNCES NEW REGULATED POWER SUPPLY 206 P A... OUTPUT FROM 500 TO 1000 VOLTS - TWO RANGES, 500 - 700 AT ¼ OF AN AMPERE; 700 TO 1000 AT .2 OF AN AMPERE... BOTH RANGES CONTROLLABLE TO WITHIN ONE PER CENT...FUSED ON PRIMARY SIDE...OVERLOAD RELAY AND TIME DELAY RELAY...SPARE FUSES...ORDERS NOW ACCEPTED...FOR COMPLETE INFORMATION WRITE, PHONE OR WIRE HARVEY RADIO LABORATORIES, INC.

DO YOUR POST-WAR PLANS CALL FOR PRECI-SION PARTS ?

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Get this new illustrated booklet and see how the Adeco organization and facilities can meet your exact specifications for close-tolerance production of parts and assemblies on a contract basis. This helpful information is yours for the asking.

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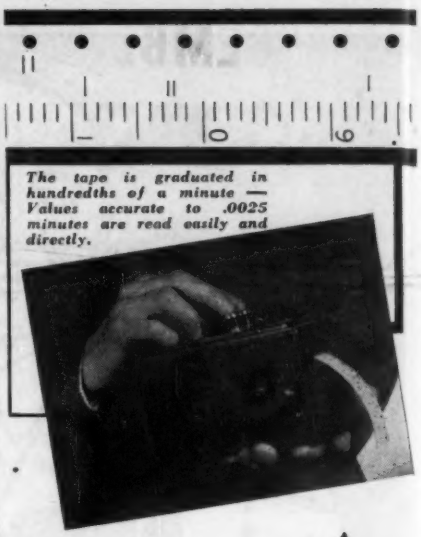
• • •

JUST LIKE A WOMAN

Girl operators of the Women's Division of the RCAF take six months training in the Wireless School at Montreal. They find that the easiest letter to learn in Morse is "Q", which reminds them of the first four notes of the "Wedding March"



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THE NEW MARSTO-CHRON GATHERS

- ✓ elemental time quickly and accurately.
- ✓ saves time because fewer observations are necessary.
- ✓ no need to combine elements — every motion recorded at the instant of recurrence.
- ✓ increases confidence between management and labor.

No watch to read . . . nothing to write down . . . time values accurate up to .0025 can be read directly, easily and accurately. Postwar competition will demand greater individual operating efficiency based on new methods and more comprehensive time studies. Now is the time to get set.

Write today . . . learn how the Marsto-Chron time study method will give you more efficient production.

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171 CAMDEN ST.
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P-K ASSEMBLY ENGINEERS "BLITZ" TWO TROUBLESOME

Tapping "Bugs"

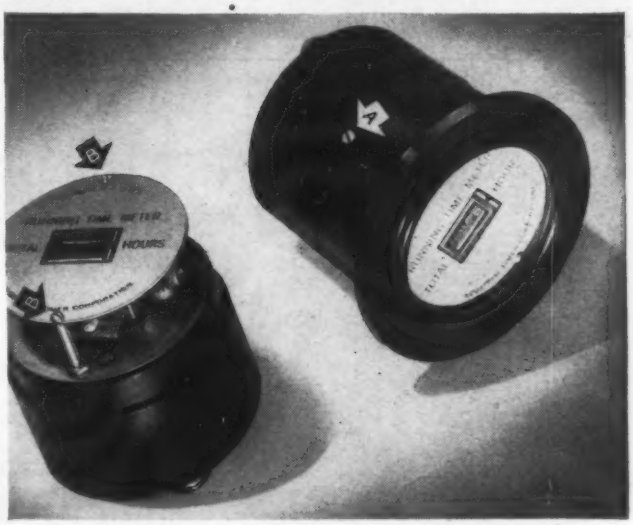
– prove the simpler P-K Fastening Method is a short cut to stronger instrument assemblies

Industrial Timer Corporation, N. J., makes numerous timing devices widely used by the armed forces and by war plants. When planning the assembly of a newly designed Running Time Meter, they first tried machine screws for two "tricky" fastenings. The result was costly tapping delays and unsatisfactory holding power.

Familiar with the advantages of P-K Self-tapping Screws from use in metal assemblies, they called in a P-K Assembly Engineer. By following his suggestions, the bothersome "bugs" were eliminated, along with both the tapping operations.

Talk to a P-K Assembly Engineer about your fastening problems. He has specialized in all types of plastic and metal fastenings, and is well-prepared to show you how to save tapping time, prevent breakage, improve strength. He'll call at your request, – or, if you prefer, send assembly details for recommendations. Parker-Kalon Corp., 208 Varick St., New York 14, N. Y.

TOUGH JOB TILL TAPPING GETS GO-BY. Fastening the plastic cover (A) to the plastic body was a tough job because a brass part lay between. When tapped for machine screws, brass chips fouled the plastic threads, holding power was poor. P-K Type "F" Screws eliminated both tapping and chip problem, assured a strong assembly.



NO FIXTURES – NO FAILURES, now that P-K Type "Z" Screws are used to fasten the brass dial plate (B) to the small hollow brass tubes that have been molded into the plastic case. With machine screws, a complicated fixture would have been necessary to hold the tubes for tapping, also tapping the tiny holes would have given constant trouble. Girls now drive the P-K Screws easily, without fixtures, into plain, untapped holes.

• P-K SCREWS ARE SOLD BY GOOD DISTRIBUTORS EVERYWHERE •

PARKER-KALON

Quality-Controlled

SELF-TAPPING SCREWS

Give the Green Light to War Assemblies

SELF-TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY

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Communication
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Complete units or any component parts now available on the following:

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RADIO AND TELEVISION CORPORATION
1030 W. VAN BUREN ST., CHICAGO 7, ILL.

PRECISION RADIO AND COMMUNICATION EQUIPMENT

Synchronized F-M Oscillators

(*Continued from page* 111)

to act as a limiter and so prevent a further rise.

Advantages of the System

At this point, the advantages of using a synchronized oscillator in an f-m receiver can be summarized as follows:

1. Selectivity to adjacent channels —at least equal to the selectivity of two i-f stages.
2. If properly designed—a synchronization sensitivity sufficient to give a voltage gain (as an amplifier) considerably better than the conventional i-f amplifier.
3. An amplitude-limiting action better than that of a conventional limiter.
4. A quieting sensitivity inversely proportional to frequency deviation of the received signal.

The fact that overall regeneration is decreased as a result of sub-

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• Much of the success of this Hudson Wire product is due to a new coating method that gives a smooth, permanently-adherent enameling. Mercury-process tests guarantee perfect uniformity; great tensile strength assures perfect laying even at high winding speeds. Especially adaptable for reduction in coil dimensions without sacrificing electrical values.
Our engineering and design facilities are at your disposal—details and quotations on request.
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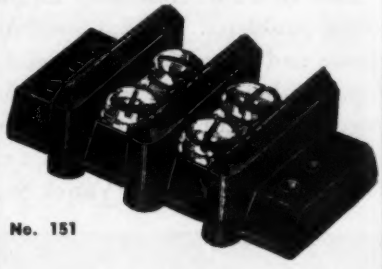
SOLVE MOST TERMINAL PROBLEMS



No. 151

A compact, sturdy terminal strip with Bakelite Barriers that provide maximum metal to metal spacing and prevent direct shorts from frayed wires at terminals.

6 SIZES

cover every requirement. From ¾" wide and 13/32" high with 5-40 screws to 2½" wide and 1⅛" high with ¼"-28 screws.

Jones Barrier Strips will improve as well as simplify your electrical intra-connecting problems. Write today for catalog and prices.

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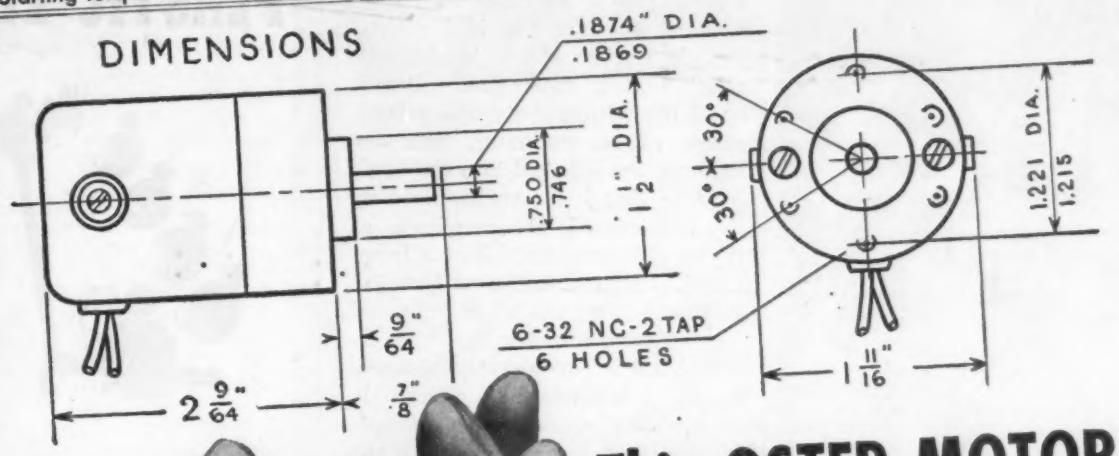
27 VOLT, SHUNT OR SERIES, CONTINUOUS DUTY IN 25° C. AMBIENT			
Maximum H.P.	1/300	1/400	1/650
R.P.M.	11,000	8,500	5,000
Amps. Input	.480	.450	.300
Starting torque in % of full load torque	250 min.	250 min.	250 min.



This OSTER MOTOR

gives you maximum performance . . . with minimum requirement for weight and space

You can depend on Oster motors to live up to the world-wide reputation of pre-war Oster appliances, and to deliver results that add to the prestige of your product for war and peacetime uses. Careful engineering and precision workmanship assure you of dependable, trouble-free performance. Let us help you fit this or other Oster motors to your requirements.

M-17

FEATURES OF TYPE A-16A OSTER MOTOR

HOUSING — die cast aluminum, totally enclosed.

FINISH — black anodized.

WEIGHT — 7 ounces.

BEARINGS — high quality single shielded ball bearings, lubricated with grease suited for any specific application. Bearing housings fitted with steel inserts.

MOUNTING — standard ¾" diameter air corps rabbet.

BRUSHES—high grade metal graphite of ample size to assure unusually long brush life.

WINDINGS — available in shunt, series and split series reversible, 12 and 24 volt, intermittent and continuous duty.

TEMPERATURE RISE — 55°C. Maximum frame temperature rise at rated load.

MODIFICATIONS — special shaft extensions, mounting arrangements, leads, etc. Also furnished for operation in high ambient temperatures and high altitudes.

APPLICATIONS — operation of small blowers, switching equipment and other similar aircraft applications.

All data and ratings are approximate.

Oster FRACTIONAL H.P. ELECTRIC MOTORS

John Oster Mfg. Co. of Illinois

Department L-17 — Genoa, Illinois

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100 MILES AWAY engineers watch the ticker tape of the Burgess-powered recorder . . . direct flight maneuvers or warn the test pilot of danger by radio. Why not bring *your* electronic problems to Burgess Engineers when portable power is involved?

FREE..ENGINEERING HANDBOOK

80-page manual of basic data and characteristics of dry batteries for all electronic applications. Tabbed for ready reference. Write Dept. 9 for *free* copy. *Burgess Battery Company, Freeport, Illinois.*

BURGESS BATTERIES

harmonic operation cannot be fairly counted as an advantage, since operation on the fundamental is practically impossible, and subharmonic operation may add to the receiver cost by requiring an automatic gain-control string.

Of the features listed, the first—selectivity—is an inherent property of any synchronized oscillator. It can be shown mathematically[18] that if two equal voltages, one lying within the synchronizing range of an oscillator, and one without, are injected into the oscillator so that it is synchronized by the first signal, the amplitude of the second signal will be greatly reduced. Physically, the explanation of this is that the effective g_m of the oscillator tube for the interfering signal is considerably reduced, since it can produce an effect only during the amplification period, which is not synchronous with the interfering signal.

With subharmonic operation, the only effect of an adjacent-channel signal is a very slight frequency modulation which may occur during the amplification periods. While the desirability of good adjacent-channel selectivity will be enhanced as the f-m band is filled up, it is doubtful whether this advantage alone is sufficient to justify the use of a synchronized oscillator, if it is used following an i-f amplifier

• • •

GIRL AND GONIOMETER

Airwoman "Petie" Houston, of Hamilton, Ont., operates a direction finder with which she traces planes in flight. She is one of a class of RCAF Women's Division students at No. 1 Wireless School in Montreal

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for the coming . . .

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• Here at Rogan, seasoned engineers are ready and willing to assist you in determining your post-war *Plastic* requirements.

Whether your peacetime products are to include electronic equipment, electrical appliances, stoves or what have you, the Rogan Organization will gladly provide cost-free advice on all phases of plastic production.

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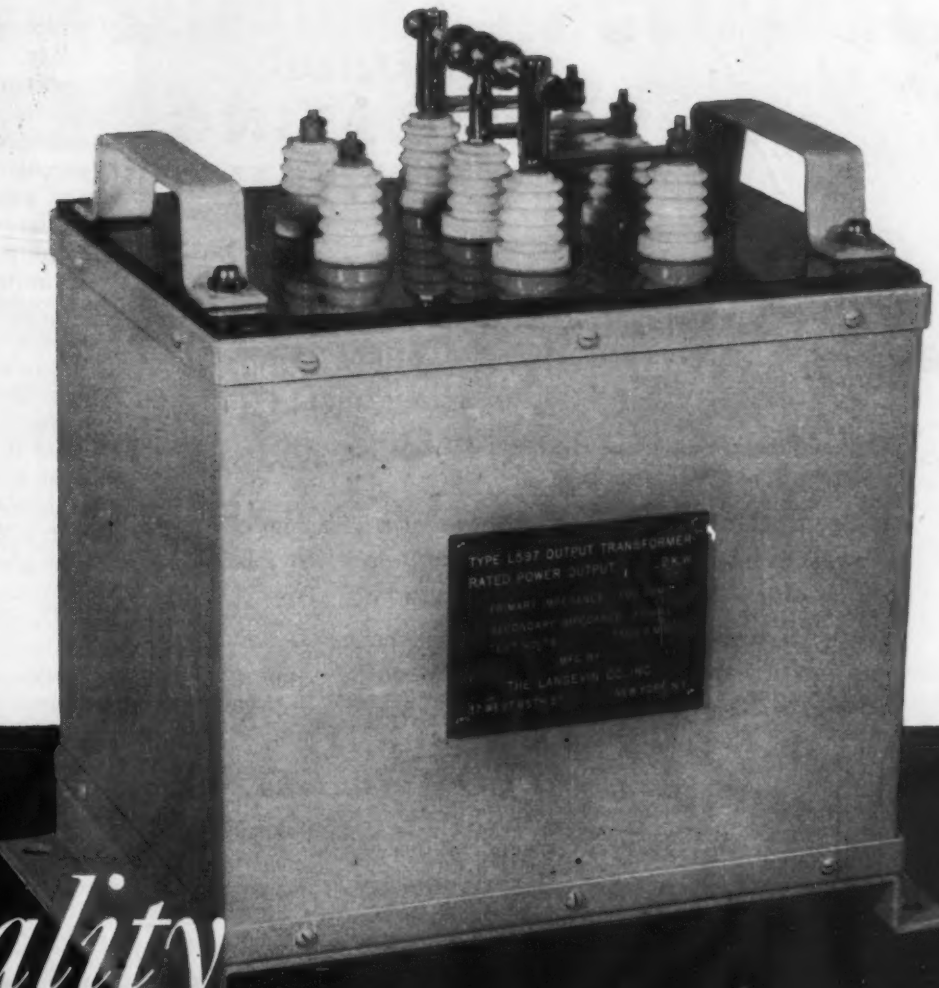

Quality TRANSFORMERS OF SPECIAL DESIGN

Illustrated above is one of the many types of special application tranformers designed and manufactured by us. We at Langevin are interested solely in the manufacture of quality apparatus, both transformer components and complete electronic units. Your inquiries for either are solicited. Transformer capacity to 5 K.V.A.

5TH WAR LOAN

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SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK	SAN FRANCISCO	LOS ANGELES
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Electrical
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Can Give You
GREATER PENETRATION • RESISTANCE TO OILS, ACIDS, ALKALI • FLEXIBILITY ABRASION RESISTANCE • FASTER PRODUCTION

You can get all of these advantages at a minimum of overall cost when you complete your electrical jobs with Pedigree electrical insulating varnish.

Why not give us an opportunity to show you how you can take advantage of these benefits — either in your present production or your postwar plans.

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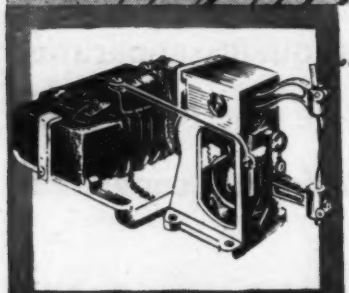
Call In the Pedigree Varnish Man Nearest You.

which already has a good selectivity.

At present, no known oscillator-limiter circuit combines perfect amplitude limiting with high synchronization sensitivity and voltage gain. While it is possible to adjust an oscillator for a high amplitude, 20 volts or more, so that it limits very well for a signal at the center of the band, the amplitude still shows a variation over the band, and the sensitivity usually drops by a factor of ten or more.

On the other hand, an oscillator with a lower amplitude level, and designed for maximum sensitivity and voltage gain, can be followed with a very simple limiter stage of the usual type, the combination giving excellent limiting action over the entire band. The use of a conventional limiter following the oscillator has the further advantage that the oscillator is separated from the frequency detector. If a conventional diode discriminator is connected directly to the oscillator

DANIEL KONDAKJIAN
TUNGSTEN LEADS



...for every electronic application!

DKE DANIEL KONDAKJIAN experience in the manufacture and fabrication of high quality Tungsten leads is both extensive and all-inclusive. Products include rigid and flexible leads for critical installations in every type of electronic apparatus and equipment.

DANIEL KONDAKJIAN engineers and technicians are available for tungsten lead collaboration. Inquiries pertaining to post-war specialties are invited.

DKE SPOT WELDER . . . The DANIEL KONDAKJIAN high efficiency spot welder offers high speed production advantages worthy of immediate consideration. Write today.

THE ENGINEERING CO.
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or
SPECIALLY DESIGNED

CAPACITORS

For the past 15 years Girard-Hopkins have built standard and specially created capacitors, designed to meet the most exacting climatic and technical conditions. Our line includes every stock type of capacitor for normal needs — Increased manufacturing capacity and a highly trained engineering staff enable us to quickly build and deliver specially designed capacitors to your specifications. Consult us on your present and post-war capacitor problems for either wax or oil types.

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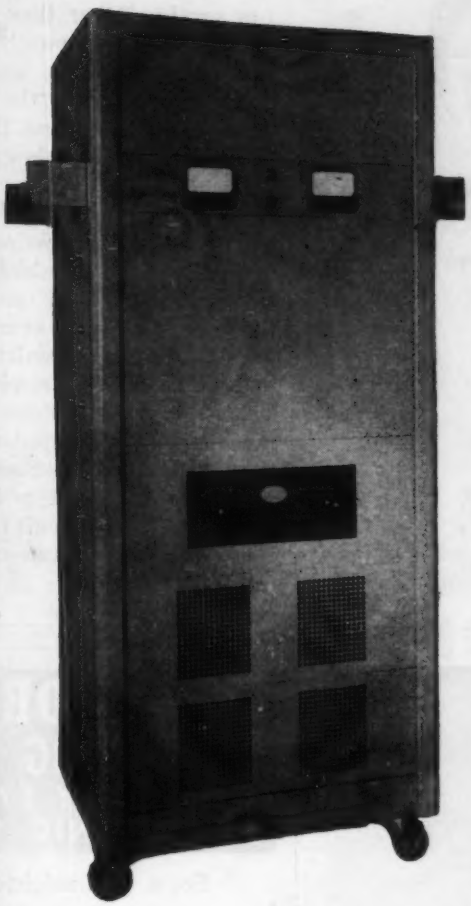
OAKLAND 1 CALIFORNIA

GREEN (Selenium) RECTIFIER



42" wide, 24" deep
Approx. 81" Tall
Capacity up to 5000 amps.
at 6 volts

Complete in ONE Cabinet with Built-in Meters and Controls

STANDARD UNITS

6 Volts—25—50—75—100—300
500—1000—1500—2000
3000—4000—5000 amps.

8 Volts—300—600—900—1200
1800—2400—3000
3600 amps.

12 Volts—600—1200—1800—2400
3000 amps.

16 Volts—300—600—900—1200
1500—1800 amps.

24 Volts—300—600—900—1200
amps.

48 Volts—300—600 amps.

Special requirements incorporating either selenium or rectifier tubes are met by engineering to individual needs.

Write Dept. E for illustrated booklet.

W. GREEN ELECTRIC COMPANY, INC.

GREEN EXCHANGE BLDG., 130 CEDAR ST., NEW YORK 6, N. Y.

RECTIFIER EST. G. 1892 ENGINEERS

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NO "SHORTS"
IN DIALCO PILOT LIGHTS
New Improvement
MAKES SOCKETS
PERMANENTLY ANCHOR-TIGHT and FOOL-PROOF!

ORIGINATED BY DIALCO, ONLY DIALCO UNITS HAVE THIS VITAL IMPROVEMENT!

Note this rugged construction: Shell, bracket, and lugs are permanently *ANCHOR-TIGHT and foolproof, preventing shorts.* Dialco manufactures an extensive line of Pilot Lights and Socket Assemblies having this feature. Write for samples and Catalogue.

PLUS LAMPS: To speed production, we can supply any Pilot Light assembled with G.E. or Westinghouse Lamps.

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CO. of AMERICA, Inc.
900 BROADWAY
New York 3, N. Y.
ALgonquin 4-5180-1-2-3

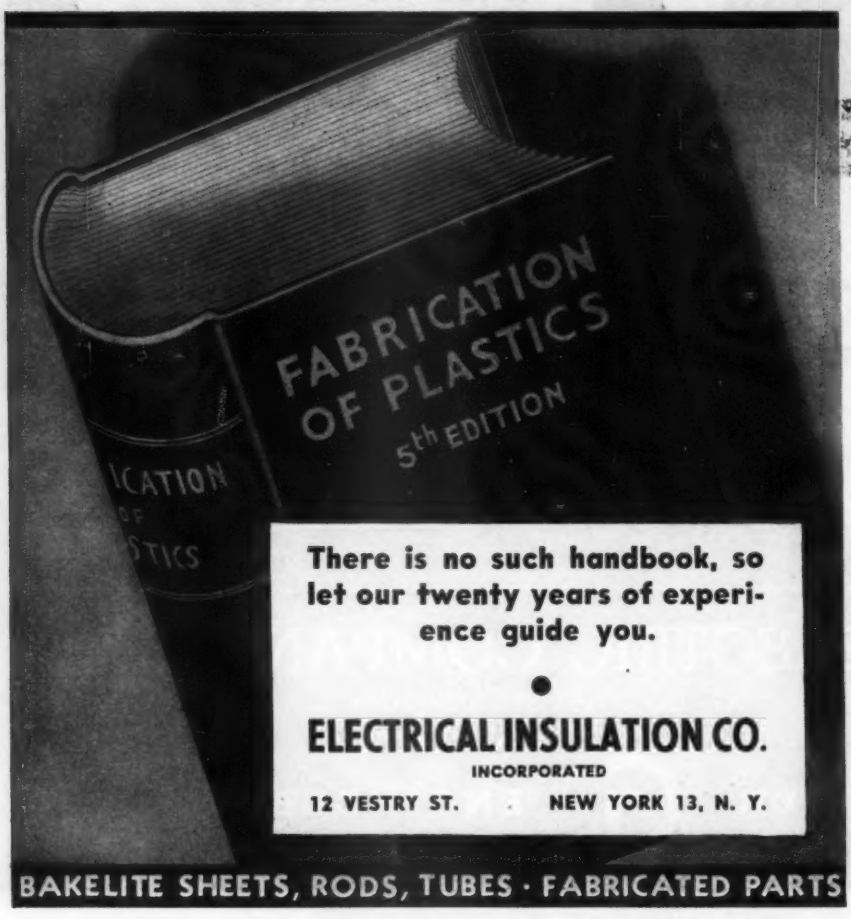
BACK THE INVASION—BUY MORE BONDS NOW!

through a secondary on the oscillator tank coil, the oscillator and discriminator alignments become interdependent, with consequent difficulties in production.

The last feature—a quieting sensitivity inversely proportional to frequency deviation—is of importance in the application of the synchronized oscillator-limiter to f-m services other than broadcast. These services generally employ a low deviation ratio, and a small quieting voltage on the limiter is very desirable because the r-f and i-f gains can be kept low and stable.

Injection of Synchronizing Voltage

In most of the previous applications of the synchronized oscillator, injection has been accomplished from low-impedance sources. Since the source of synchronizing voltage in a practical f-m receiver is the last i-f stage, problems arise because of the high impedance of this circuit. Coupling between the oscillator tank circuit and the synchronizing input circuit must be reduced to a minimum in order to ob-



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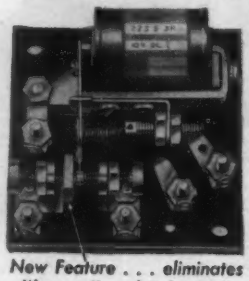

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tain normal gain from the i-f stage.

Figure 6 shows a typical synchronized-oscillator circuit using a type 1852 tube with the synchronizing voltage developed in the grid circuit. Oscillation is maintained by a cathode tickler winding. Because of the grid-to-cathode capacitance, part of the oscillator voltage across the tickler is developed across the input tuned circuit which at the same time works as the plate load for the last i-f amplifier.

Normal gain of an i-f amplifier is $g_m Q\omega L$, which might be 50 for an f-m i-f amplifier. If the oscillator operates at the fundamental, the loading effect due to the reflected oscillator voltage is so great that the amplifier gain practically disappears. With subharmonic operation, a gain of 10 in the preceding i-f amplifier is obtainable. Thus most of the gain in the oscillator itself may be lost by the reduction of gain in the preceding stage.

As mentioned, the Russian solution to this problem was the use of a pentagrid mixer, in which the first section acted as a buffer be-

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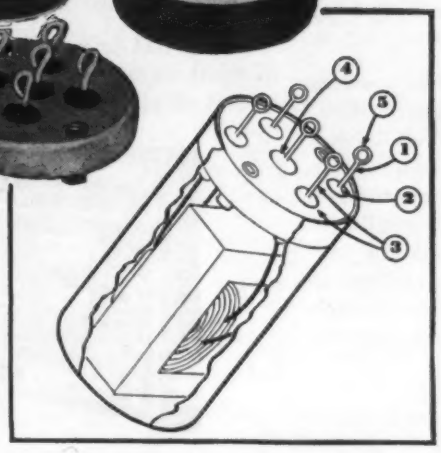

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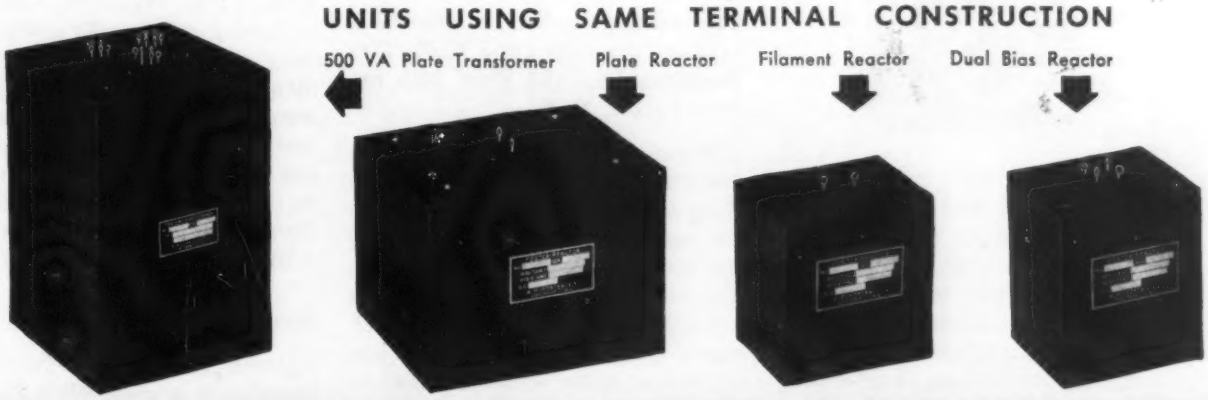

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Phase Inverter Circuit

In the August issue of its monthly magazine, CREI NEWS, The Capitol Radio Engineering Institute continues its series of interesting technical articles. The coming issue deals with an interesting type of phase inverter circuit, particularly suitable for wide band operation, such as for a cathode-ray oscilloscope.

Part I, which appears in the August issue, describes the circuit, compares it with other types of phase inverter circuits, and analyzes its basic action.

A second article on the phase inverter circuit will appear in the September issue of the CREI NEWS. It will evaluate its gain and its stability under variable operating conditions.

We are making these technical articles available to every interested radioman. If you want to receive these articles on the phase inverter circuit, and other articles to follow, merely write to the Capitol Radio Engineering Institute, and ask for the August issue of the CREI NEWS containing this article. This and other future issues will be sent to you free and without obligation.

★ ★ ★

The subject of "Phase Inverter Circuit" is but one of many that are being constantly revised and added to CREI lessons by A. Preisman, Director of Engineering Texts, under the personal supervision of CREI President, E. H. Rietzke. CREI home study courses are of college calibre for the professional engineer and technician who recognizes CREI training as a proven program for personal advancement in the field of Radio-Electronics. Complete details of the home study courses sent on request. . . . *Ask for 36-page booklet.*

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tween the input circuit and the oscillator. Unfortunately, with present tube structures this method has two disadvantages. First, it is impossible to obtain the desired g_m in the oscillator section if the electron stream is already limited by the first grid. Second, because of the low g_m, suppression of subharmonic oscillations occurs at a considerably lower level than is the case with high g_m pentodes. It is expected that by using different injection methods and tube structures, these difficulties will be overcome.

Even though the loading effect in the oscillator input circuit is reduced to a negligible amount, enough coupling may still exist between the oscillator and the i-f circuits to introduce hysteresis into the oscillator. The worst offender in this connection is stray coupling between the oscillator and the input to the i-f amplifier. An amount of coupling which ordinarily is acceptable in production will cause the oscillator to jump suddenly from one frequency to another during alignment, and make its correct adjustment impossible in production. Subharmonic operation overcomes this to a large extent, since the harmonic content of the oscillator is not large without an injected signal. Normal precautions must be taken to reduce overall feedback from the oscillator, however, even with subharmonic operation.

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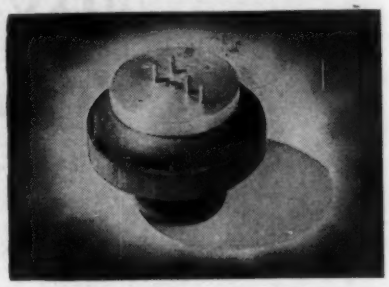

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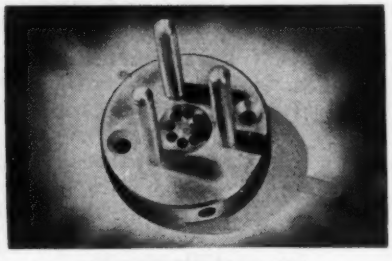

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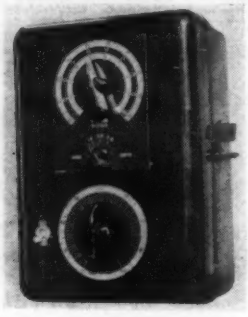
General Electric Products

THREE NEW PRODUCTS are available from General Electric Co., Schenectady, N. Y.

THE FIRST OF THESE, available from the Industrial Control Division, is a new tempering attachment, (CR7503-D149), for use with G. E. synchronous spot-welding controls which incorporate the phase-shift method of heat control. The attachment is particularly suitable for use in the spot-welding of air-hardenable steels, since it permits tempering the weld while the work is still in the machine. The attachment consists of a heat-control and a time-control adjuster for tempering, and the relays which automatically transfer the additional heat-



and-time adjustment from the spot-welding control with which the attachment is being used. The attachment is enclosed in a metal case designed for wall mounting. The calibrated adjustment dials are mounted on the hinged door of this case, together with an on-off switch for preventing the relays from being energized when ordinary spot or pulsation welding is being done. Bulletin CEA-4201 is available on this unit.

FORMEX ribbon-rectangular magnet wire is now available as thin as 0.004 inch and can be applied where round wire previously had to be used. It increases the winding-space factor and may be used in place of larger size, rectangular magnet wire to increase magnetic effect or to reduce coil size. The wire is smooth, strong, flexible, and able to withstand high-speed winding without damage to insulation. The manufacturer states that its dielectric strength and the wire's resistance to abrasion, heat-shock, and solvents, is greater than that of other enameled wire.

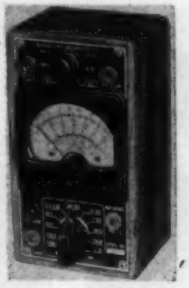
FOR AIRCRAFT electric systems there is available standard dust-tight enclosures which come in various lengths. They are designed to house combinations of contactors, relays, and other devices usually required in control systems for airplanes. The enclosures are light in weight and provide ready accessibility to devices. They may also be used as junction boxes.

Radio City Products

THE FOLLOWING THREE new products are available from Radio City Products, Inc., 127 West 26th St., New York 1, N. Y.

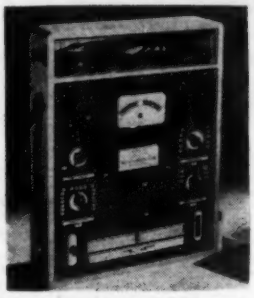
MODEL 422 Supertester is for general circuit testing. Its features include current measurements in both a.c. and d.c. up to 25 amperes; voltage measurements in both a.c. and d.c. up to 5,000 v; high voltage is not applied to the selector switch nor to general test circuits. It has a 3-inch sq meter with movement of 200 microamps, or 5,000 ohms per volt sensitivity on d.c. voltage measurements. Resistance measurements can be made up to 10 megohms. The batteries are replaceable without the use of a soldering iron.

MULTITESTOR MODEL 420 is compact and rugged and measures 6⅜ x 3½ x 3 in, open faced, and weighs 25 oz. The meter movements are guaranteed to be accurate within 2 percent. The voltage multipliers are a metallized matched pair of resistors having a tolerance of 1 percent. The basic meter is rated 0.400 mic-



roamps. D-C meter, output meter, milliammeter and ohmmeter provide a total of 23 ranges. A-C and d-c voltmeter is rated up to 5,000 v at 1,000 ohms per volt sensitivity. It comes supplied with batteries.

MODEL 314 is a tube tester. The filament voltage switch is designed to test all present filament voltages



from 1.1 to 117 volts. Lever type switching individually controls each tube prong, checks roaming filaments, and dual cathodes. The instrument provides separate plate tests on diodes and rectifiers and has a neon short test. The meter is rectangular and measures 4½ inches and has a poor-good scale. A pilot light indicates on-off.

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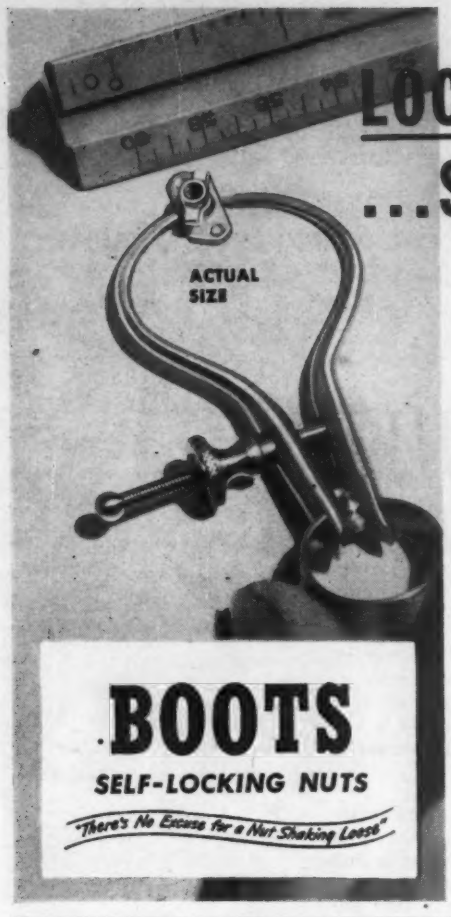

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The other tube is 6AQ6, which is a miniature multi-unit tube containing two diodes and a high-mu-triode in one envelope. Many of its electrical characteristics are similar to those of the metal type 6Q7, but it requires only half the heater current and has appreciably lower grid-cathode and plate-cathode capacitances. The tube is designed for use as a combined detector, amplifier, and automatic-volume-control tube. Its small size facilitates the design of small, compact receiver units.

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Aircraft Relays

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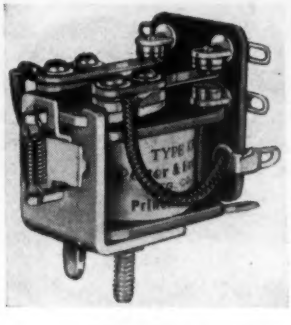
The KR Series are sturdy relays designed for applications where size and weight are important factors. Where current is not too limited, the d.-c. types can be adjusted to withstand the vibration encoun-



tered in most aircraft applications. The relays can be provided with a mechanism for easy adjustment of armature spring where a critical pull in value of current or voltage is required. Contacts are normally supplied in silver. They are rated at 3 amp, 110 v, 60 cps, noninductive load. Coils are available for

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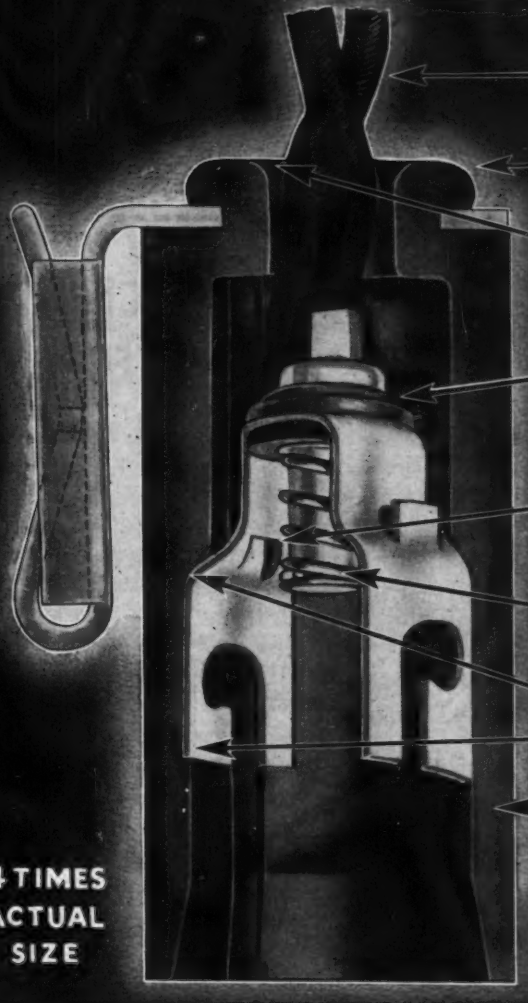

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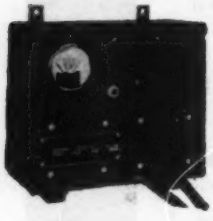

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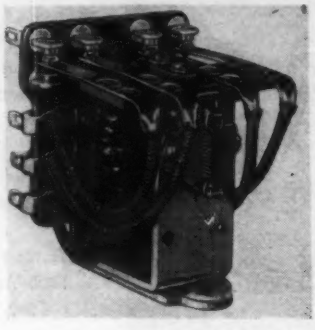
311 S. Western Ave., Chicago 12, Ill.

PHONE: CANAL 2525

voltages up to 110 v, 60 cps, or 60 v, d.c. Contact arrangements may be had up to and including DPDT. In this series is included Type KRD-4 which measures 1 11/16 x 1 1/4 x 1 7/8 in., not including the mounting stud. The unit weighs 1 3/4 to 2 oz and is designed to mount in two holes.

The KL Series have approximately twice as much coil space and a larger number of poles than the



KR Series. These relays will operate on values as low as 0.2 watts. The contacts are normally supplied in silver, and are rated at 3 amp, 110 v, 60 cps non-inductive load. Coils are supplied for voltages up to 220 v, 60 cps, or 110 v, d.c. Contact arrangements are available up to and including 4 pole DT. Type KLD-1 of this series measures 1 11/16 x 1 11/16 x 1 11/16 in., and weighs 3 1/2 to 4 oz.

Potter & Brumfield Mfg. Co., 150 N. First St., Princeton, Ind.

Low-Frequency Crystals

A NEW TYPE OF patented low-frequency crystal has been developed by The James Knight Co., Sandwich, Ill.

This crystal can be made to operate on frequencies from 300 kc to 10 kc. The temperature coefficient, over minus 40 to plus 50 deg C, can be made less than 1 part per million per deg C. The frequency can be increased or decreased by contour grinding. The decrease, however, is limited to about 200 cycles at the 100 kc frequency. The crystal is also available in dual frequencies of 100 and 1,000 kc, using a longitudinal vibration for the low frequency, and the thickness mode for the higher frequency. The crystal can be used in air-gap mountings or can be plated and clamped at the nodal point.

Sherman Offers QUICK DELIVERY On Hundreds Of Styles of ELECTRICAL TERMINALS

One of the largest, most complete lines of Electrical Terminals available anywhere, is offered you by Sherman. Hundreds of styles are available, and others are constantly being added. Most of these are kept in stock, ready for quick shipment.

Sherman probably has a stock terminal exactly suited to your own particular requirements. If not, we would be happy to have you submit your specifications to our engineering departments.

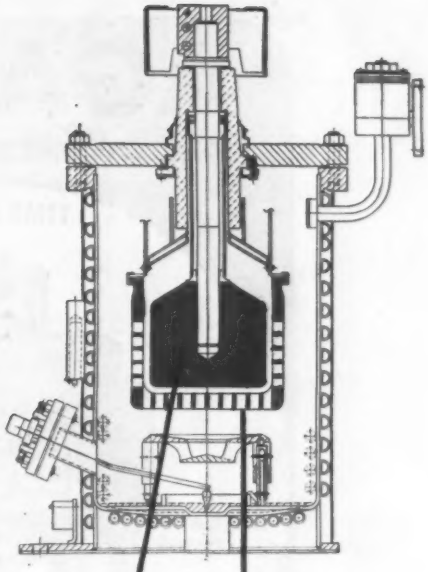
Sherman also makes many other high quality electrical fittings, such as soldering and solderless lugs, fuse clips, etc. Write today for Sherman catalog.

H. B. SHERMAN Mfg. Company
Battle Creek
Michigan

Sherman

LUGS, TERMINALS, FUSE CLIPS

"Unless you can express it as a *Number* you have no information"



THAT'S AN UNWRITTEN LAW in many laboratories today. Because "National" graphite's purity—99.979%—could be expressed as a number, the manufacturer's engineers knew what its performance characteristics would be when used as the anode and anode shield material in this Ignitron Rectifier.

Across the nation, banks of these rectifiers are serving war plants, traction companies, shipyards and mills efficiently and dependably.

Engineers have long known that graphite does not fuse, soften or warp, and has nearly perfect heat radiation properties. Thus, in many types of both vacuum and gas-filled industrial and radio tubes where great heat must be dissipated, or where warpage of multiple tube components must be prevented, graphite is the ideal material.

As pioneers in the carbon and graphite manufacturing business in America, National Carbon Company has brought to highest perfection the art of making high-purity graphite. That is why "National" High-Purity Graphite is most frequently specified for vital industrial and radio tube components. Graphite of even higher purity is supplied for some applications. We welcome the opportunity to discuss the advantages of this "National" electronic graphite.

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

General Offices: 30 East 42nd Street, New York 17, N. Y.

Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

The registered trade-mark "National" distinguishes products of National Carbon Company, Inc.

BUY UNITED STATES WAR BONDS

Conforming to American War Standards

PANEL INSTRUMENTS by ROLLER-SMITH

With more than 40 years of experience in the design and manufacture of precision electrical instruments, Roller-Smith is producing a wide variety of 3.5" miniature panel instruments that meet all requirements of A.S.A. War Standard C-39.2-1944. Made in a full range of types and capacities, these panel instruments are built to Roller-Smith high standards of precision and dependability. Furthermore, our expanded production facilities are permitting us to speed deliveries. Write today, outlining your panel instrument needs.

OTHER R-S INSTRUMENTS

Panel, switchboard and portable instruments of practically every standard size, shape, capacity, type and style are included in the line of R-S instruments. The circuit tester at the right and flush-mount miniature ammeter at the far right are typical of the fine time-tested instruments that bear the R-S mark. Write today, outlining your instrument requirements.

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Sales Representatives In all Principal Cities

ROLLER-SMITH BETHLEHEM, PENNA.

Canadian Plant: ROLLER-SMITH MARSLAND LTD., Kitchener, Ontario

STANDARD AND PRECISION ELECTRICAL INSTRUMENTS OF EVERY TYPE

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and
MILES
of small
EXTRUDED PLASTIC ROD

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Complete facilities for automatic spooling and winding.

Let us figure on your requirements

CARTER PRODUCTS CORPORATION
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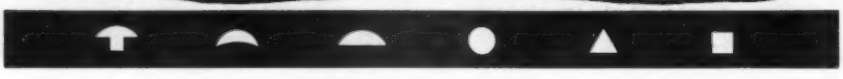
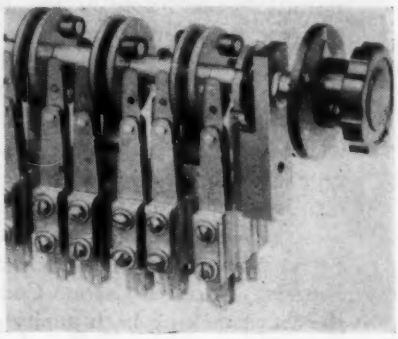
Plate below shows a few of the many shapes



Rotary Cam Lever Switch

THE NEW ROTARY cam lever switch is designed for one to six index positions. Any combination of spring-leaf contact assemblies is available for each of the six positions. Practically any number of circuits in sequence (or repeat) can be opened or closed by the use of a single control knob. One hole is required in the panel for mounting, and contact assemblies in any section can be removed from the frame by removing one bolt. Other features of the unit include spring



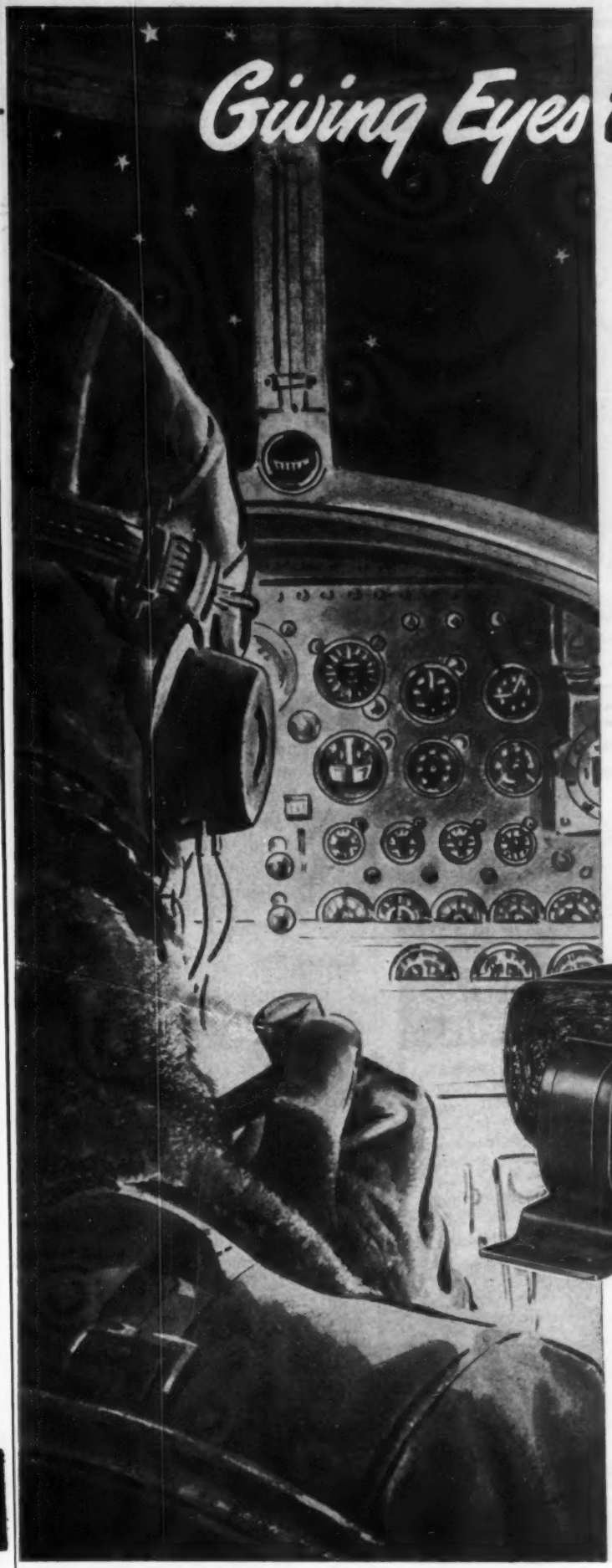
type actuators, cast aluminum frame, Bakelite cams and rollers, static-shielding nickel-plated phosphor bronze contact springs, solid silver contacts, circular cams for locating up to 12 low-friction spring-type actuators, and contact build-ups assembled under pressure. The switch is rated at 10 amp, 125 v a.c., and is built to meet Government specifications.

General Control Co., 1200 Soldiers Field Road, Boston 34, Mass.

Hardware Kit

FOR LABORATORY WORK there is available a 1500-piece radio hardware kit which is housed in a 18-compartment clear plastic box, consisting of small, medium and large 6-32, 8-32 and 10-32 screws with service binder, washer and rounded heads, nuts and washers, as well as assorted lock washers, Parker-Kalon self-tapping screws, spade bolts, rivets, plus switch and volume control hardware. Most of the hardware is made of brass stock with assorted finishes including nickel, copper, oxidized, cadmium and parkerized.

Walker-Jimieson, Inc., 311 S. Western Ave., Chicago 12, Ill.



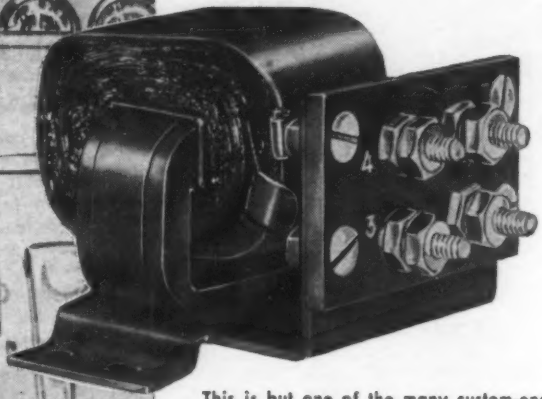
Giving Eyes to War Birds

. . AT 50,000 FEET AND — 57.4 DEG. F

To the combat pilot, high up in the inky blackness of night, the glowing instruments are more than a mechanism . . . they're his security, his strategy and his return ticket! These lights must not fail!

To further this dependability in aircraft lighting systems, the N-Y-T Sample Dept. has produced the 8 ounce transformer illustrated—lighter in weight by 40% than any component of the same output previously used.

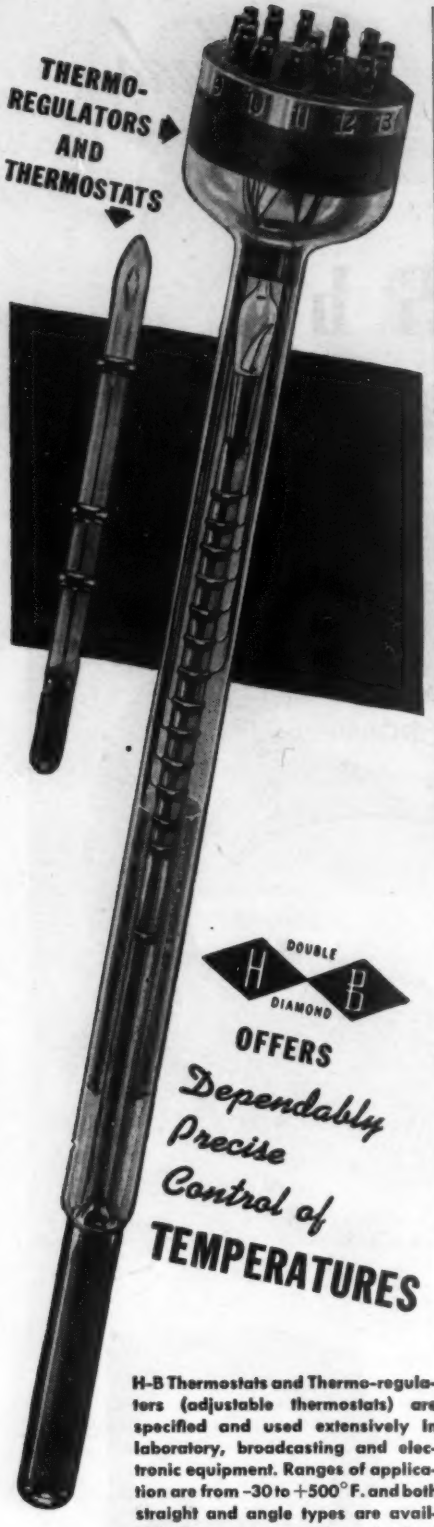
Conservative, from the standpoint of electrical and mechanical characteristics, this N-Y-T unit has a temperature rise of only 30 deg. C. and permits operation over all ambient from minus 65 deg. C. to plus 70 deg. C. Its diversity of application is illustrated by the fact that output voltages and currents may be varied without affecting size and weight, if the output is held to 30 V.A.



This is but one of the many custom-engineerings executed by N.Y.T. technicians, in hastening Victory through electronics; similar transformer products will aid immeasurably in the fulfillment of peace-time advancements.

NEW YORK TRANSFORMER CO.

26 WAVERLY PLACE
NEW YORK 3, N. Y.



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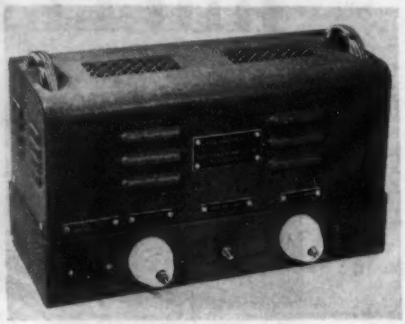
H-B Thermostats and Thermo-regulators (adjustable thermostats) are specified and used extensively in laboratory, broadcasting and electronic equipment. Ranges of application are from −30 to +500° F. and both straight and angle types are available. Temperatures can be maintained with these instruments to an accuracy of a fraction of a degree. Many shapes and sizes now available for shipment. Write for Blue Book No. 4 . . . For more than 27 years, H-B has been producing specialized precision instruments in large and small quantities for the measurement and control of temperature. Relays, thermometers, manometer tubes and other H-B units are standard in the field. Call on us for assistance in your problems.

H-B INSTRUMENT COMPANY

2524 No. Broad Street, Philadelphia 32, Penna.

Electronic Switch

TRIGNITROL designates a silent, positive-acting, electronic switch for use in welding equipment. Designed to supersede mechanical switching on capacitor-type welders, it instantly and completely discharges the capacitor bank through the welding transformer with minimum damage to metal grain structure and no burning of surrounding metal. The switch utilizes a Trigniton, which is a new mercury-



pool-conduction tube fired capacitively by a low-power trigger circuit. The switch is immune to flashback and oscillatory discharges. While the control circuit must be reopened before the Trignitrol will recycle, the speed of operation is only limited by the capacitor recharging intervals. Power supply is 110 or 220 v 60 cps, a.c.

Electronic Power Co., Inc., 18 West 44th St., New York 18, N. Y.

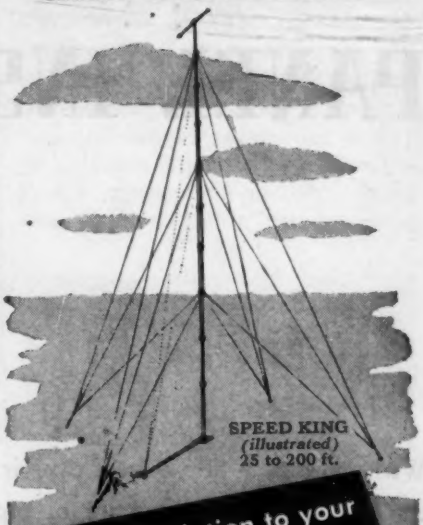
Timing Devices

SERIES 5900 comprises synchronous motor-operated automatic reset time delay and interval timers for time delays of one second to five minutes with fixed or adjustable intervals. The units are available with various assemblies of actuating arms, reset springs, terminal mountings and precision snap switches, NC, NO, and DT. For applications involving shock and vibration, the motors can be equipped with a shift-counterweight assembly. The motors are also available with special plating and other protection against high humidity, corrosion and fungus growth. These same units, designated as 5148 series, are available for d.c. operation.

Haydon Mfg. Co., Inc., Forestville, Conn.

HARCO

RADIO MASTS and TOWERS



are the solution to your PROBLEMS (present or post-war)

because—

1. **LOW TRANSPORTATION COST.** Shipping expense reduced to a minimum because total weight and shipping space is extremely small. Also low storage and handling costs.

2. **MINIMUM ERECTION COST.** Speedy erection insured—due to elimination of Bolts and because customary erection labor expense has been reduced by shop fabrication. All connections reduced to simplest form.

3. **CAN BE ERECTED WITH INEXPERIENCED LABOR.** HARCO MASTS AND TOWERS are easy to put up. Emphasis placed on portability—no sections are too heavy for one man. No skill required for making connections. None of the usual hazards exist. Ground assembly optional.

4. **CAN BE ERECTED UNDER ADVERSE CONDITIONS.** Erection accomplished under all weather conditions and extreme temperatures by men wearing gloves. Rigid construction is the result of all sections having a high strength-weight ratio, and the type of connections and bracing used. Every safety precaution possible has been taken.

Whatever your problems may be, HARCO can solve them from every Engineering angle. If none of our 16 Standard Designs meet your requirements, we can give you a "Custom Built" job.

Please send complete design specifications when inquiring for detailed information.

HARCO

STEEL CONSTRUCTION CO., Inc.

Elizabeth 4, New Jersey

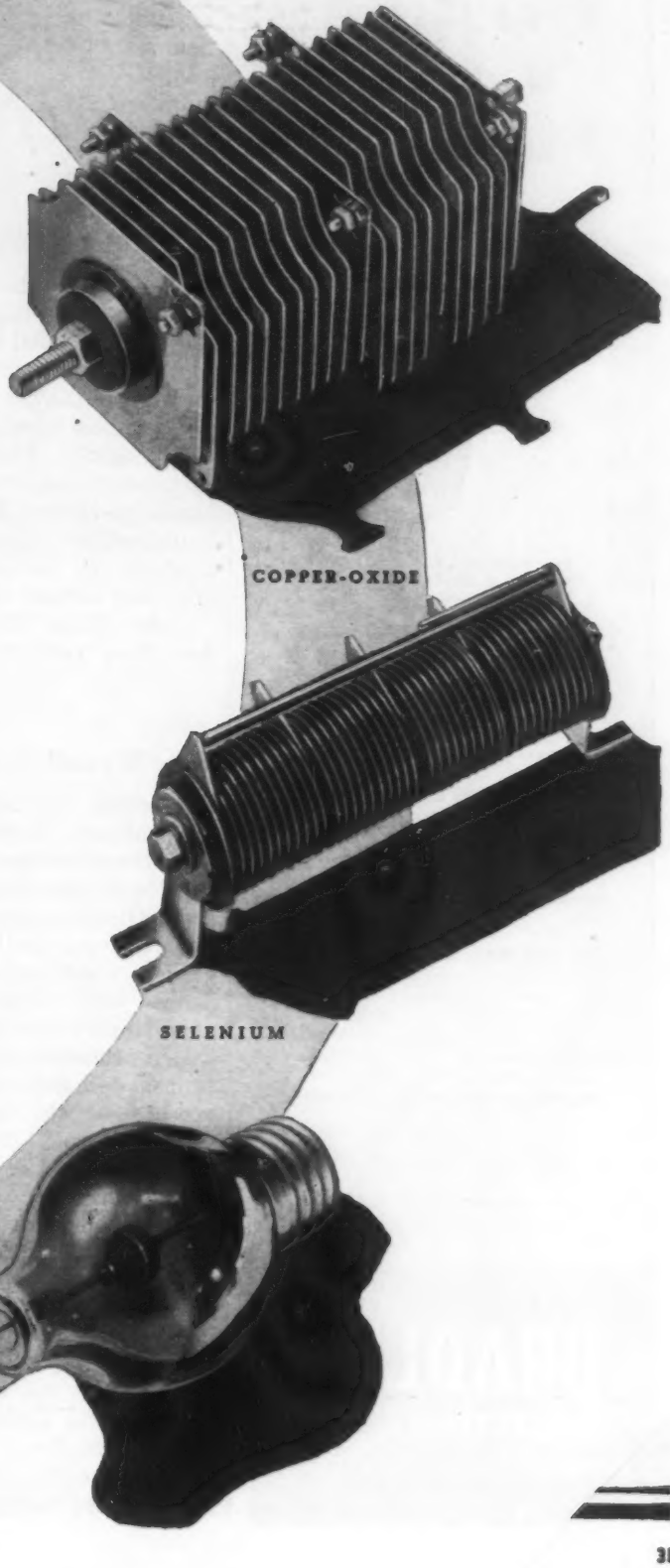
Only GE Offers All Three

Low-voltage Rectifiers

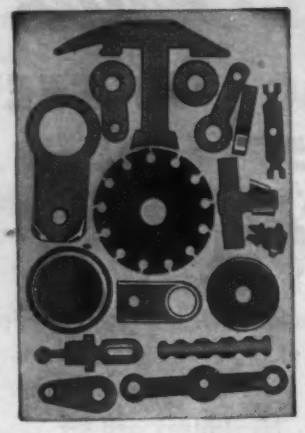
Where other manufacturers offer one or two of the three standard types of low-voltage rectifiers, General Electric is alone in supplying all three—an important fact to remember when next you need a rectifying unit. The reason: The most efficient type in one application may be least efficient on the very next application. It is in determining which type to use in each instance that G.E. can help you most—having all three types it can give impartial engineering advice on which one you should use. Full details from Section A844-119, Tungar & Metallic Rectifier Division, General Electric Co., Bridgeport, Conn.

Hear the General Electric radio programs: "The G-E All Girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news, every weekday 6.45 P.M. EWT, CBS.

GENERAL ELECTRIC



DO YOU NEED—



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D.C. to A.C.

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Janette
D.C. to A.C. CONVERTERS
When only D.C. power is available, A.C. Electronic devices can be operated by using dependable JANETTE rotary converters. Many thousands are in use on ships, shore stations, as well as for domestic applications. Built in the 5 styles illustrated, for 6 to 230 volts D.C. input to 110 and 220 volts, 1 phase, 60 cycle A.C. output. Ask for bulletin No. 13-25.
Dynamotors are also available.

Wherever there are ships, you will find Janette converters.

Janette Manufacturing Company
556-558 W. Monroe St. Chicago, Ill.

Pocket-Type Circuit Tester

THIS TESTER is designated as Type HTD. It is designed to determine the resistance of an electrical circuit with the scale reading directly in ohms. It is available with a range from zero to 10,000 ohms, or with two ranges from zero to 5,000 and zero to 50,000 ohms. The unit weighs 19 oz, and measures 4½ x 3 x 1½ in. It consists of a small d'Arsonval, type d.c., voltmeter which is

connected in series with a standard flashlight battery. Terminals are provided for connecting to the circuit under test. The plate on the front can be removed to replace the dry cell battery and also gives access to the internal zero adjuster. Catalog No. 123-b on this instrument is available from Roller-Smith Co., Bethlehem, Pa.

Chest Set

THIS CHEST SET, designated as TD-3, is a Signal Corp item designed for use between a microphone and a transmitter and consists of a chest unit, equipped with a switch; a junction box; two cotton webbing straps; and two cords for connecting a throat or lip mike to a transmitter. It has a three-way toggle switch (on, off and momentarily on). The complete unit or any component part is available from Trav-Ler Karenola Radio & Television Corp., 1036 W. Van Buren St., Chicago, Ill.

New Power Supply Units

SELENIUM RECTIFIER power supply units of 1, 5 and 10 amps capacity at 115 v d.c. constitute a new line of such units designed for use in the operation of magnetic equipment, d-c motors, relays, circuit

STANDARD FREQUENCIES—*Octaves of them*

FREQUENCIES

10, 20, 40, 60, 80, 100, 120, 140, 160, 180, 190

Accuracy: 10 parts in 1,000,000
Output: 30 volts at 500,000 ohms
Input: 105-125V, 50-60c, 40 watts
Weight: 50 pounds

Impossible? Well, here it is—

This Multi-frequency generator furnishes the frequencies shown above at the turn of a switch. All frequencies are obtained from a temperature-compensated tuning fork and voltage-stabilized circuit.

With this unit it is possible to calibrate oscillators at many selected points without encountering complex oscilloscope patterns. One of the uncertainties involved in development work on tuned circuits, filters, reeds—and in time measurement can be minimized with the aid of this instrument.

Developed primarily to check frequency meters for precision war work, this Multi-frequency generator possesses a rugged durability and dependability in service that will prove an extra value to many laboratories.

Additional information available on request.

Manufacturer of the Watch Master

and distributor of Western Electric Watch-rate Recorders

American Time Products, INC.

580 Fifth Avenue New York 19, N. Y.

LUXTRON*
PHOTOCELLS

Give Simple Means of Precision Control

This pigtail-contact model is only one of a series of mountings and indicates only one of the complete range of Luxtron* cell shapes and sizes available.

Circuit simplicity contributes to a constant flow of power. The ability of Luxtron Photocells to operate instruments and instrument relays, without amplification, removes the hazards of complex circuits.

This fact alone recommends their application to precision control problems. Another quality is their exceptional resistance to vibration, shock and general mechanical violence. These factors assure long service and unusual adherence to calibrated accuracy.

Engineering inquiries are always welcome.
Illustrated data sent on request.
*Reg. U. S. Pat. Off.

BRADLEY
LABORATORIES, INC.
New Haven 10 Conn

breakers, carbon arc lamps, battery chargers, and other similar devices. Other capacities are available on request from the manufacturer. The units are designed for wall or bench mounting and require no special connections. They are equipped with a 6 ft input lead with male connector and a standard convenience receptacle for the output. The 10 amp unit is furnished with an 11-point selector switch for maintaining 115 v from no load to full load.

Federal Telephone & Radio Corp., Newark, N. J.

Industrial X-Ray Unit

MODEL 50 KV industrial x-ray unit is for low kilovoltage x-ray inspection of light metal alloys, spot-weld control, micro-radiography, thin sections of heavier metals and articles of low density such as plywood, plastics, leather, glass, textiles, porcelains, ceramics and biological specimens. The unit is self-contained, shockproof, rayproof and is rated for continuous operation over long periods of time.

Picker X-Ray Corp., 300 Fourth Ave., New York 10, N. Y.

Wire-Wound Surge Resistors

DEVELOPED FOR x-ray and other high-voltage applications, Type 290 wire-wound surge resistors are capable of handling high voltage, and dissipating normally 200 watts. The resistors are wound on high-grade, non-hygroscopic ceramic forms with insulated Nichrome wire, single layer space-wound. The wire is protected with a finish which re-insulates and resists heat and operates on 450 deg F. Any resistance from 1,000 to 3,000,000 ohms is available. The manufacturer cites as a typical application of these resistors their use in the constant potential d.c. output of a high-voltage Kenetron rectifying system to stabilize the performance of the apparatus to which this high potential is being applied, with the resistors operating either as bleeders or as voltmeter multipliers.

Shallcross Mfg. Co., Jackson and Pusey Aves., Collingdale, Pa.

COPROX
RECTIFIERS

Include Many Extras for Longer Life

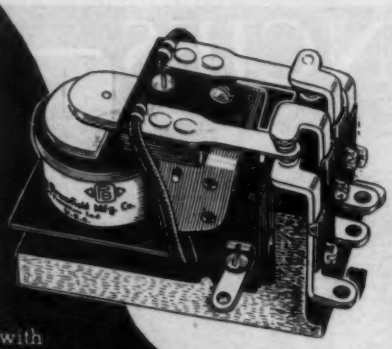
"Coprox" Model CX-1C2B1, a center tap, full wave rectifier. Completely enclosed in Bakelite. Low capacitance. Rectifies high frequency current. Conservatively rated up to 4.5 volts A.C., 3.0 volts D.C., 500 microamperes D.C. Other models and capacities to meet all needs.

Special terminals, or pre-soldered lead wires, prevent overheating during assembly. Standard units sealed with waterproof lacquers, critical-application units potted in wax. Standard "pellets" gold coated on front surface, forming positive contact; for critical applications, gold used on both sides. High leakage, but very low forward resistance. Highly adaptable mountings.
To these extras, add Bradley's ability to produce "Coprox" rectifiers for special applications, then:

Ask for samples and full technical data.

BRADLEY
LABORATORIES, INC.
82 Meadow Street New Haven 10, Conn

Phenolic Base
SP RELAYS
for radio and
communications equipment



Compact and shockproof, the SP Relay has been especially designed as a general purpose relay with the ability to withstand shock and vibration. Molded phenolic base makes it particularly resistant to the corrosive action of salt water and weathering. Ideal for communications equipment of all kinds, radio equipment, aircraft equipment and other applications. AC and DC types.

WRITE FOR NEW DESCRIPTIVE CATALOG

Potter & Brumfield
Princeton, Indiana
"THE POSITIVE ACTION RELAY"

A few reasons why **PERMOPIVOTS** *are now*
THE ACCEPTED PIVOT
with precision instrument makers everywhere

PERMOPIVOTS have emerged with an excellent record from both laboratory tests and long periods of actual use under trying conditions. As a result PERMOPIVOTS are now generally accepted by manufacturers as the pivot that keeps precision instruments accurate longer.

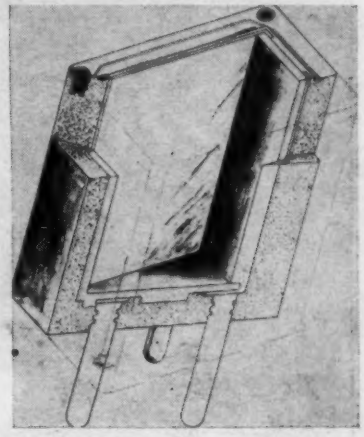
PERMOPIVOTS cannot rust or corrode. Their satin-smooth tip is non-abrasive . . . eliminates abrading particles of wear. Oil is eliminated by PERMOPIVOTS extremely low coefficient of friction.

Write today for your copy of this informative booklet

PERMO, Incorporated
Manufacturing Metallurgists
6415 Ravenswood Ave., Chicago 26, Ill.

Quartz Crystal Holder

SP-3A HOLDER for quartz crystals is suitable for use with certain aircraft and Navy crystals, and is designed so that it contains no crevices, strands of wire, or hollow pins which can hold foreign material. The surfaces of the holder may be washed clean before sealing. Solid



pins, imbedded in plastic, are used to make the holder strong and act as an added precaution against foreign material. Pins and contact plates are made of stainless steel to prevent corrosion under adverse conditions.

Henry Mfg. Co., 2213 Westwood Blvd., Los Angeles 25, Cal.

Fungicidal Concentrate for Waxes

THIS CONCENTRATE is the newest development in a line of fungicides developed in collaboration with military engineers. The concentrate may be used in various insulation and sealing waxes. It does not volatilize or lose potency at bath temperatures, and it is non-toxic to humans and therefore will not cause dermatitis.

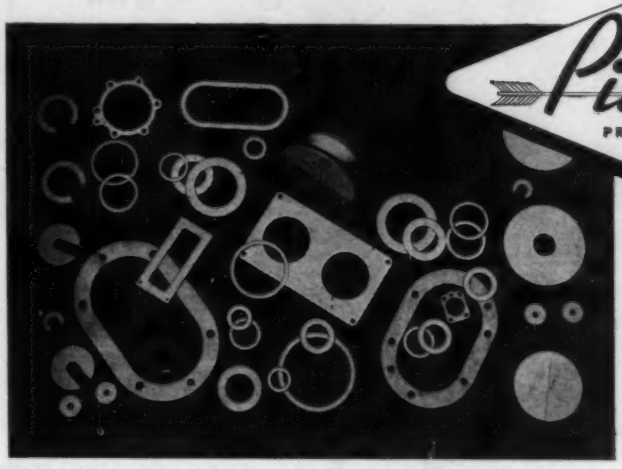
Insl-X Co., 857 Meeker Ave., Brooklyn, N. Y.

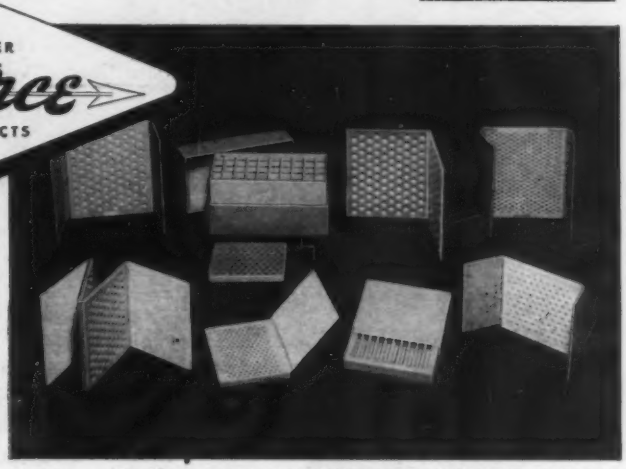
Extruded Tubing

THOUGH THIS newly developed vinyl tubing, designated Natvar 400 Series, has the same electrical properties as conventional tubing, the manufacturer states that it has better heat endurance characteristics, resistance to oil embrittlement and resistance to gasoline-benzol. Wires insulated with it may be soldered without special care or technique

We Can Make These For You...Now

SEND US YOUR SPECIFICATIONS ON STANDARDIZED ITEMS, OR LET US HELP DEVELOP NEW USES TO MEET YOUR NEEDS. WE ARE EXPERIENCED PAPER CONVERTERS . . . HAVE A NEW, UP-TO-DATE PLANT . . . AND ARE IN A POSITION TO SERVE YOU WELL AND PROMPTLY





INDUSTRIAL GASKETS; DIE CUT SPECIALTIES

Pierce industrial gaskets: manufactured to precision dimensions from paper, felt, cork, asbestos, synthetic rubber, leather or special compositions; meet specifications for resistence to oil, water, gasoline, heat, pressure. Die-cut specialties: produced by rotary press, platen press, punch press, or drawing methods from paper, felt, cork, special compositions.

NEW...SAF-T-PAK BOXES FOR SMALL PARTS

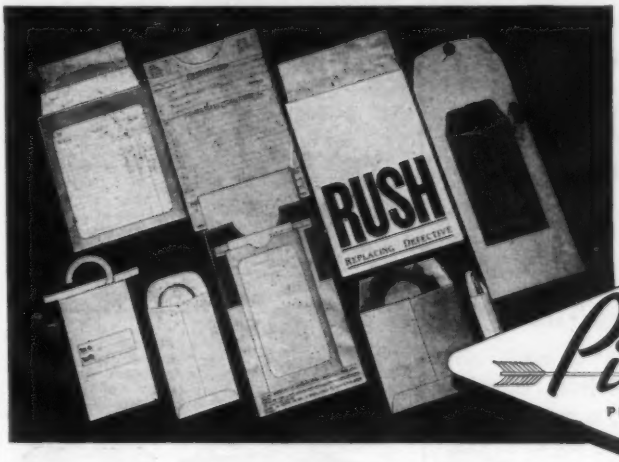
Pierce Saf-T-Pak Boxes: specially designed to individual requirements for the protection of small precision parts and other fragile items easily damaged in shipment. Can be produced from kraft, chipboard, or special compositions in a wide variety of forms with die-cut cells, cushion liners, partitions, other construction features of protective packaging.

PACKAGING AND SHOP PRODUCTION ENVELOPES

Pierce packaging envelopes for holding small flat parts; metal-top envelopes for secure fastening and convenient reopening; waterproof and greaseproof envelopes to meet all specifications; duplex shop-order envelopes — with protective glassine panels: the modern method of keeping blueprints and production orders together during work in progress.

SPIRAL-WOUND PAPER TUBES AND CANS

Pierce spiral-wound tubes and cans: in diameters from 3/16" to 6" — any required length — from waterproof paper, kraft, chipboard, special compositions. Also, Pierce Saf-T-Pak tubes with felt liner for protection of fragile parts in shipment. Pierce protective caps and tubes for male and female threads: made in any size, waxed or plain.



PAPER Pierce PRODUCTS

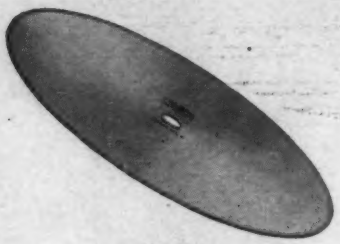
★ *WRITE FOR SAMPLES AND COMPLETE INFORMATION*

Manufactured by **PIERCE PAPER PRODUCTS CO., 2726-B AUBURN STREET, ROCKFORD, ILLINOIS**

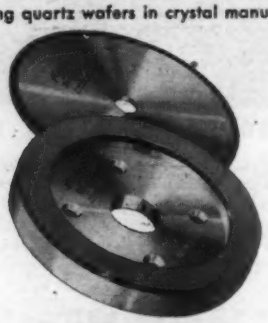
DI-MET

DIAMOND WHEELS AND HONES

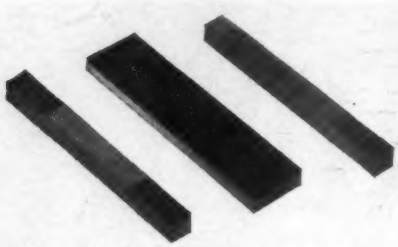
For all diamond grinding, cutting and lapping operations.



DI-MET RIMLOCK
DIAMOND ABRASIVE BLADES
For slicing quartz wafers in crystal manufacture



DI-MET METAL and RESINOID BONDED
DIAMOND ABRASIVE WHEELS
For quartz and sintered carbide cutting and grinding operations.



DI-MET DIAMOND HONES
For finishing quartz crystals and carbide cutting tools.

FELKER MANUFACTURING CO.
1116 BORDER AVE.
TORRANCE, CALIF.
FELKER DI-MET
Manufacturers of
DIAMOND ABRASIVE WHEELS

and without flow or opening of the tubing near the point of soldering. It is tough, resistant to tear, and has tensile strength in excess of 3000 psi, with elongation from 170 to 410 percent depending on the type of tubing. It remains flexible down to −80 deg F. The tubing is chemically inert and is suitable for oil lines, sheathing and other protective coverings in applications where adverse oil, solvent or acid conditions are severe, and where protection from chemicals or vibration is required over a wide temperature range.

The National Varnished Products Corp., Woodbridge, N. J.

Molded Mica Capacitors

THREE TYPES OF capacitors have been added to the manufacturer's line of "El Menco" capacitors. Type CM-20 comes in two types which include No. 503J and 603J.

Both of these have cases which measure $\frac{11}{32}$ x $\frac{7}{16}$ x $\frac{3}{32}$ inches, with wire terminals measuring 0.032 inches in diameter and $1\frac{1}{4}$ in. long, thinned brass. No. 503-J (foil) is rated at a capacity range from 2.5 to 1500 $\mu\mu$f, maximum working volt from 800 to 300, and minimum tolerances rated from ± 10 percent to ± 5 percent. No. 603J (silver) has a capacity range of 2.5 to 1000 $\mu\mu$f, maximum working v of 500; and a minimum tolerance of ± 2 percent. The third type is designated CM-40 (604L silvered). Case dimensions are $1\frac{3}{32}$ x $\frac{11}{32}$ x $\frac{13}{32}$ in. Wire terminals measure 0.040 inches, in diameter and $1\frac{3}{8}$ in long, thinned brass. Capacity range is from 470 to 10,000 $\mu\mu$f; maximum working voltage is 500; and ± 2 percent minimum tolerances.

The Electro Motive Mfg. Co., Willimantic, Conn.

Precision Welding Timer

SUITABLE FOR WELDING small objects of high conductivity such as aluminum or copper, a new precise welding timer, designated as SP-18, is available with heat control for timing intervals of one-half cycle or less. The timer is designed for welding of such items as radio tube parts and sockets, pig-tail resistors

University

REFLEX SPEAKERS

DESIGNED for WAR USE

★ HIGH EFFICIENCY ★

★ RUGGED CONSTRUCTION ★

★ HIGH POWER ★

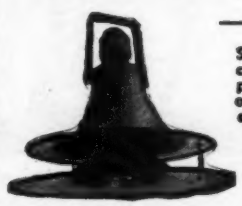
★ UNIFORM RESPONSE ★

★ HIGH INTELLIGIBILITY ★

★ WEATHER PROOF ★

★ REFLEX SPEAKERS ARE THE ACCEPTED STANDARD FOR ALL WAR USE

Every high efficiency speaker in University's extensive line of speech power reproducers has a vital part in the WAR program.



Submit your special loudspeaker problem direct to our engineering department.

UNIVERSITY LABORATORIES
UNIVERSITY
125 VARICK STREET

1000 B.C.

Illustration taken from Continental's instruction manual shows proper method of sanding this multi-bar commutator.

1000 Volts **B**etween **C**oils is the operating voltage of these engine driven generators being built for the Signal Corps by *Continental Electric Co., Inc.* of Newark, N. J.

They are tested at 3000 volts—three times their normal voltage. Yet compact design allows only minimum clearance between coils!

Natvar varnished acetate and Natvar varnished silk were chosen by *Continental* for this important application because they are *thin*, because they have *high dielectric strength*, and because they are *uniform*.

What are *your* insulation problems? Write, wire or phone us for deliveries, either from stocks located near you, or from our own.

Natvar

- Varnished cambric—straight cut and bias
- Varnished cable tape
- Varnished canvas
- Varnished duck
- Varnished cellulose acetate
- Varnished Fiberglas cloth
- Varnished papers
- Varnished tubings and sleevings
- Varnished identification markers
- Lacquered tubings and sleevings
- Extruded Vinylite tubings
- Extruded Vinylite identification markers

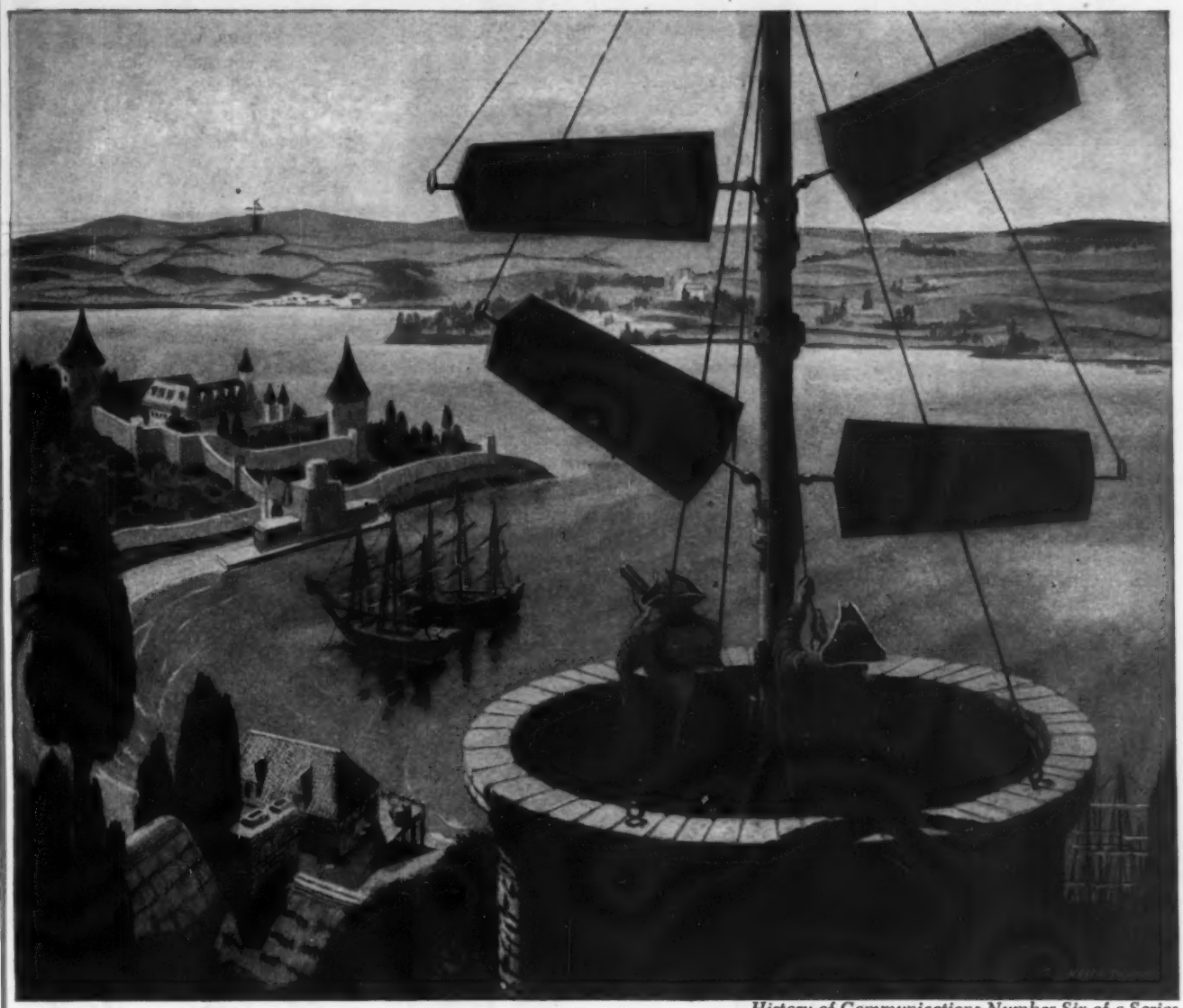
THE NATIONAL VARNISHED PRODUCTS Corporation

TELEPHONE
RAHWAY 7-2171

CABLE ADDRESS
NATVAR: RAHWAY, N. J.

201 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY

8-NVP-6



History of Communications Number Six of a Series

COMMUNICATION BY SEMAPHORE

The Semaphore, as a means of communication, met first commercial acceptance in France under the authority of Napoleon in 1792. Restricted by "line of sight" and low power eye pieces, excessive numbers of relay stations, as pictured above, were required for "directional broadcasting" over rough terrain. Weather conditions, too, were a handicap. Because of the code used and its necessary translation, delays and errors were continually encountered.

Today, in the era of applied electronics, Universal microphones are being used to expedite messages on every battle front in the service of the Allies. Universal is proud of its contribution in the electronic voice communications and its every effort to our ultimate Victory.

Model T-45, illustrated at left, is the new Lip Microphone being manufactured by Universal for the U. S. Army Signal Corps. Shortly, these microphones will be available to priority users through local Radio Jobbers.

UNIVERSAL MICROPHONE COMPANY
INGLEWOOD, CALIFORNIA

FOREIGN DIVISION: 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA ·· CANADIAN DIVISION: 560 KING STREET WEST, TORONTO 1, ONTARIO, CANADA

We serve not only as Custom Moulders but also offer complete assembly service. We solicit inquiries on war work and invite consultation on future planning.

For information on our Standard Navy and Maritime Fittings consult Graybar Electric Company.

Northern Industrial Chemical Company

7-11 ELKINS ST., SO. BOSTON 27, MASS.

35 YEARS OF PLASTIC MOLDING EXPERIENCE

MEMBER OF THE SOCIETY OF THE PLASTIC INDUSTRY

Electrodes for Crystals

BUTTON TYPE. FLAT OR STEPPED TYPE

•

SQUARE, OBLONG AND ROUND

•

CLOSEST TOLERANCES

•

EXCELLENT FINISH

MINIMUM LAPPING

GREAT SAVINGS IN MAN HOURS AND COSTS

PROMPT DELIVERIES

Send for full information

Gemex Company

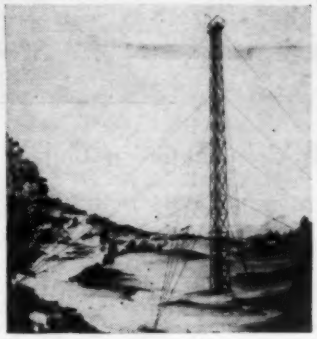
UNION, NEW JERSEY

to terminal lugs, watch and instrument parts, contact tips on electrical relays and other small parts. The instrument is furnished as a separate control for use with existing small bench welders in combination with a small welding transformer. One control tube is used, and this thyratron serves the dual purpose of rectifying alternating current to charge a firing capacitor and also firing the small ignitron power tube. Heat control is accomplished by a phase-shift method, the adjustment dial for which is mounted on the cabinet door. The timer is rated at 230/460 volts, 50/60 cps.

Department 7-N-20, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Radio Tower

BANTAM KING is the name of 30, 50 and 100-ft steel towers made of interchangeable four-foot sections each six feet in height. The towers are easily and quickly installed, and may be used as a portable or permanent units. They may be used for vhf and fm radiators, rotary or stationary beam antennas, or for radio-range and radio beacon systems.

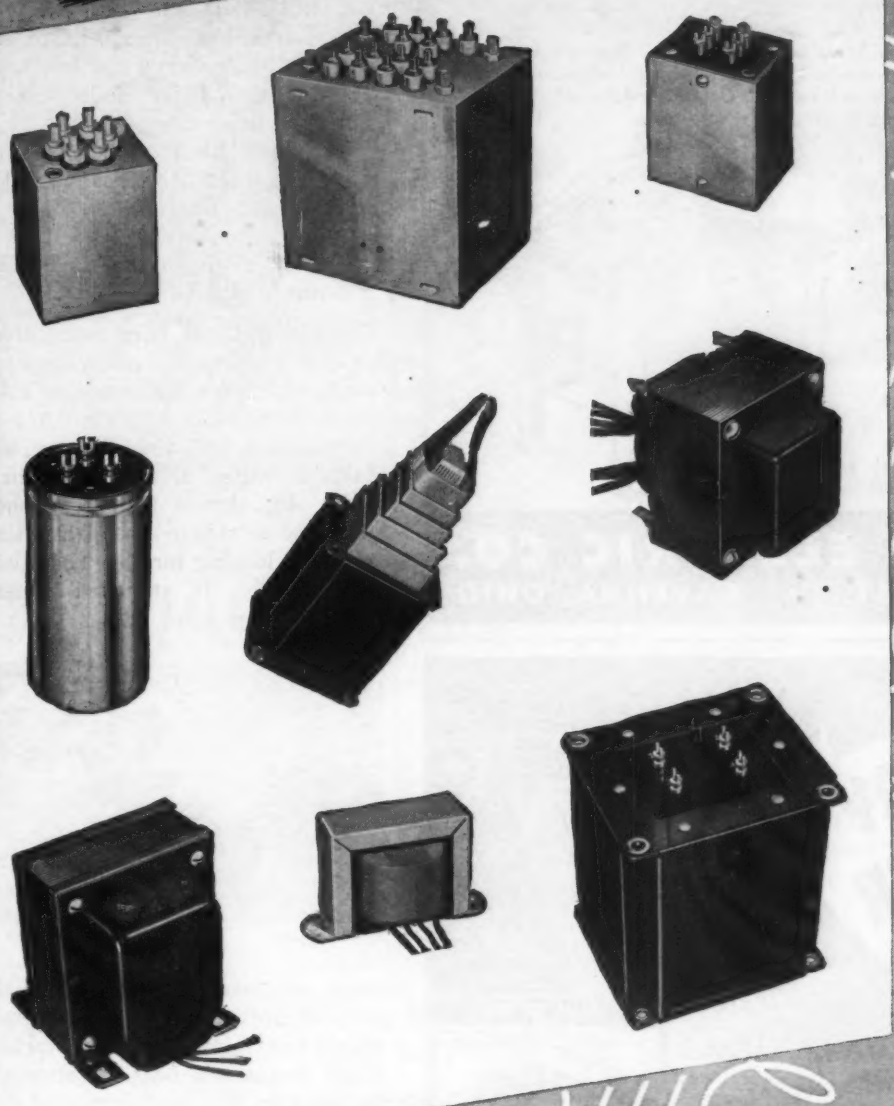


Harco Steel Construction Co., Inc., 1180 East Broad St., Elizabeth 4, N. J.

Fungus Resistant Coatings

THESE FOUR NEW moisture and fungus resistant coatings for war equipment have been approved by the Signal Corps. They include: Tuf-On No. 74-F Bakelite resin varnish which takes 12 min to set, and 1 hr to dry hard; Tuf-On No. 74-M which is also a Bakelite resin varnish. It takes 5 min to set and 45

MEET THE FREED TRANSFORMER FAMILY

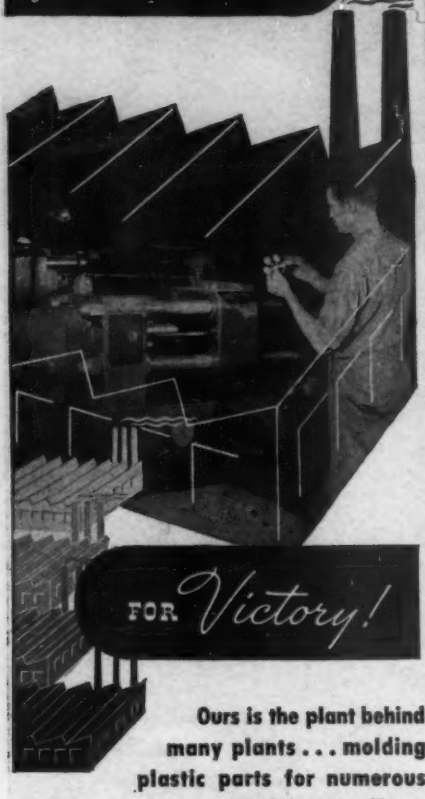


This is the first in a series of advertisements designed to inform you about Freed Transformers. The spectacular wartime developments originating in the Freed Laboratories are worthy of a page in Electronic History! The ingenious applications; the engineering efficiency; the reliable, unfailing performance of Freed units — all built to exacting specifications — are tributes to the resourcefulness and sound, basic knowledge of our engineering staff. . . . This staff is available to assist you, and we urge any engineer struggling with an intricate problem to submit it without delay.

FREED TRANSFORMERS

FREED TRANSFORMER COMPANY · 74 SPRING STREET · NEW YORK CITY

Plastics from VICTORY*



FOR Victory!

Ours is the plant behind many plants . . . molding plastic parts for numerous contractors who are supplying the Navy, the Army Air Forces, and the Signal Corps.

Molding millions of precision plastic parts for the Armed Forces is still our big job, but we have the time, the equipment and a highly skilled staff to handle a limited number of new contracts—and do a better molding job, *on time.*

Whether for production now, or after the War, our engineers are ready to work with you immediately. Write us today and let us know your molding problems.

Member: Society of the Plastics Industry

Automatic Injection Molding

Small and large parts

UP TO 17-OZ. SHOTS

Lumarith, Tenite, Fibestos, Plastacelle, Crystallite, Lucite, Ethyl Cellulose, Polystrene, Lustron, Styron, Vinylite, Loalin, Cellulose Acetate and others . . . all molded to your exacting specifications.

*VICTORY MANUFACTURING COMPANY

1724 W. Arcade Place, Chicago 12, Ill.

ESTABLISHED 1930

min to dry hard; Tuf-On No. 58-F coating which dries very hard in 10 min, and takes 5 min to set; and Tuf-On No. 58-M coating which also takes 10 min to dry hard, and 5 min to set. The drying times are based on testing methods as given in Signal Corps Specifications.

The manufacturer recommends the varnish types No. 74-F and No. 74-FM for the protection of rigid parts and assemblies because of their high moisture resistance, dielectric strength and good adhesion. No. 58 is for use where considerable flexibility in the coating is required such as for wire, and where a good fire retardant quality is desirable. This coating is also for use in applications where better protection has to be sacrificed for speed of production.

Wipe-On Corp., 105 Hudson St., New York, N. Y.

Wide-Range Oscilloscope

TYPE 248 oscilloscope is a wide range, portable instrument which consists of two units, namely the oscilloscope and the power supply connected by a 6 ft plug-in, shielded cable. A removable cover protects the oscilloscope panel when the instrument is not in use. The power supply unit weighs 80 lb and the oscilloscope unit weighs 30 lb. Each unit measures 14 x 18 x 21 in. The vertical amplifier is usable to 10 Mc. A delay network in the vertical channel permits observation of the entire wave shape of short-duration phenomena.

Allen B. DuMont Laboratories, Inc., Passaic, N. J.

Exponential Rule

THIS RULE ATTEMPTS to give a graphical presentation of natural and common logarithms, exponentials and reciprocals; giving direct and without interpolations the characteristics and mantissas of numbers ranging from 1. up to 100,000, and from 1. down to 0.00001. It is an improvement over the rule released in 1932.

Louis B. Sklar, 816 North Sixth St., Philadelphia, Pa.

HEXACON

ELECTRIC SOLDERING IRONS

Light-weight!

Less operator fatigue . . . easier manipulation . . . rapid, uniform heat — these are a few of the features responsible for the wide popularity of HEXACON electric soldering irons.

Constructed for maximum operating efficiency, HEXACON heating elements are housed in damage-proof, hexagon-shaped barrels for protection from mechanical injury. High heat alloy cores resist scale and prolong element life. Insulation breakdown tested for twice the requirements of the Underwriters' Laboratories.

WRITE FOR LITERATURE

Descriptive bulletins, describing the complete line of HEXACON electric soldering irons, will be sent on request.

HEXACON ELECTRIC COMPANY

130 W. CLAY AVE., ROSELLE PARK, N. J.

HEXACON

"RE-CONVERSION LAG" . . . will it hit you hard?

Your company's race to capture post-war markets will depend greatly upon the speed with which key production men can shift from war to peacetime manufacturing and assembly.

This critical transition time can be materially shortened if plans for your production include knowledge of preferred equipment, tools, methods, sources and specifications.

Where, for instance, would you turn for newest methods of impregnating with heated compounds under pressure or vacuum? Or, for spraying heated compounds from a pressure spray tank? Or, melting Korogel? Or, spraying Nylon?

You'll find the Sta-Warm Production Engineering Service Department well stocked with ready answers to these and other similar questions. Use of Sta-Warm electrically heated tanks, kettles and pots before the war, plus greatly expanded applications by war contractors, provides a backlog of data now available to you. For factual information about melting, conveying or dispensing heated compounds and soft metals, write to Sta-Warm.

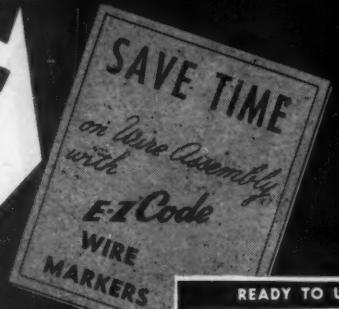
Have you latest bulletin no. 036? Ask for it today.

100 gal. pressure impregnating tank with counter balanced top.

STA-WARM ELECTRIC CO.
1000 N. CHESTNUT ST. • RAVENNA, OHIO

SEND TODAY for THIS FOLDER

TELLS HOW TO QUICKLY AND EASILY **CODE WIRES**



Save Time on
• NEW INSTALLATIONS
• WIRE ASSEMBLIES • MAINTENANCE JOBS

E-Z CODE Wire Markers come on handy cards. They are simple to use, stick quickly, no moistening, stay on and stand abuse.

Our standard types fit most coding requirements, although special codes, sizes and arrangements can be made to your specifications. Prompt deliveries.

Write today to

WESTERN LITHOGRAPH COMPANY
Dept. A4, 600 East 2nd St., Los Angeles 54, California

E-Z Code WIRE MARKERS

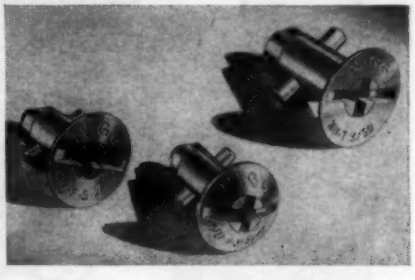
Electronic Heating Unit

HEATER UNITS for electronic heating in such applications as brazing and soldering, melting metals, bombarding tubes, surface hardening, sealing packages, and glass bonding to metals are available for frequencies up to 300 megacycles, and in power ranges of 3, 5, 7½, 10, 12½, 15, 18, 25, 40 and 100 kw, with stepless control from zero to full load. The heater units are especially designed for their particular applications.

Scientific Electric, Div. of "S" Corrugated Quenched Gap Co., 119 Monroe St., Garfield, N. J.

Fastener Studs

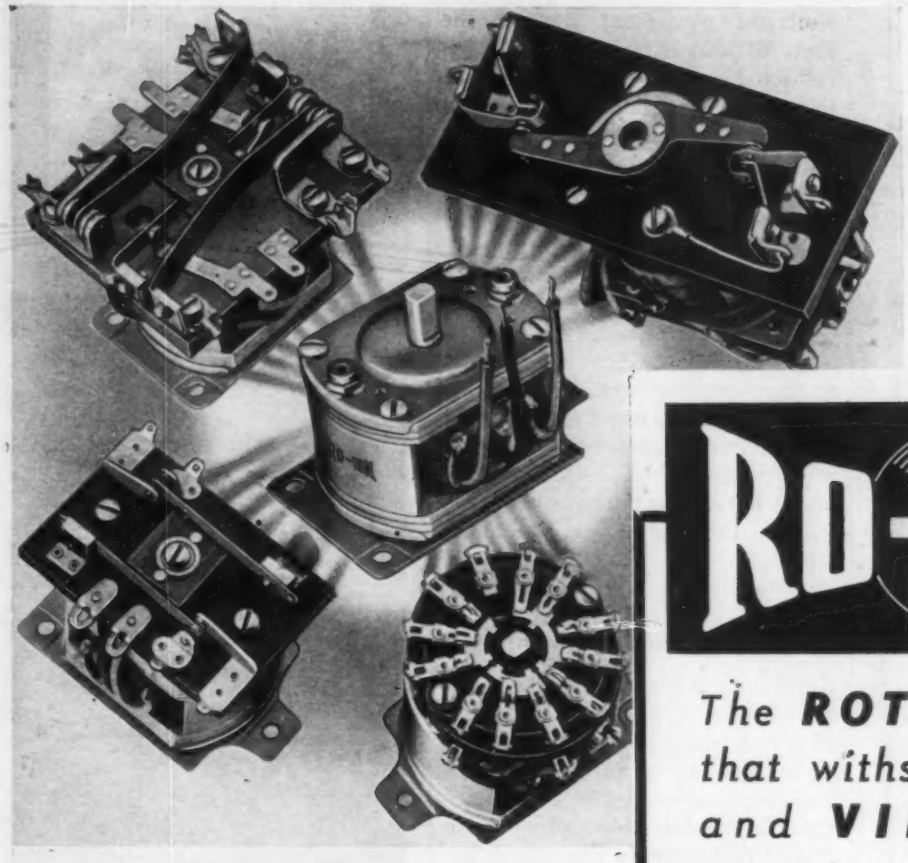
ONLY A QUARTER turn is required to lock or unlock these new fastener studs which can accommodate total sheet thicknesses of from 0.021 to 0.500 inches, and which have an adjustable range of nearly one-half inch. Adjustment is accomplished from the outside to any desired tension and locking torque. The studs are available in standard dimensions, are interchangeable with all snap or spring-type fasteners and will fit existing pin-type receptacles. Badly damaged or bent surfaces can be securely fastened immediately. Illustrated (from left to right) are types NU-F-5, NU-V-5 and NU-7.



Nigg Engineering Co., Covina, Cal.

Silicone Resins

NEW ORGANO-SILICON polymers, designated as "Silicones" are now commercially available for applications essential to the war effort. The manufacturer states that these silicone resins, when used for electrical insulation, extend the range of operating temperatures possible in



HERE'S A NEW RELAY

RO-TROL

The ROTARY RELAY that withstands SHOCK and VIBRATION!!

Ro-Trol is a new basic relay unit, operating on a rotating balanced principle, instead of the conventional method. It was developed especially to withstand the severe shocks and vibration of war planes, tanks, ships, etc.

WIDE ADAPTABILITY

The basic Ro-Trol unit is adaptable to a wide variety of Wafer and Multiple contact arrangements. It is most compact, the basic unit measuring: 2½" x 1½" x 1¾". Electronic engineers in both military and private fields have proclaimed "Ro-Trol" a great advance in Relay Engineering.

SEND FOR CATALOG RE-48

This portfolio gives complete engineering data about Ro-Trol and other types of Relays we manufacture. It should prove useful whenever you have need for Relay applications. Get a copy today.

The "HUSKY" Line

includes many other styles of Relays and Controls . . .

As a result of 30 years of experience we have also developed a complete line of relays for radio transmitter and general control applications, including: Time Delay Relays, Motor Starting Relays, High-speed Keying, and Power Contractors.

30 YEARS OF "KNOWING HOW"

We manufacture in our own plant practically everything that goes into our products. We are equipped to furnish a standard diversified line as well as to manufacture equipment built to particular specifications.

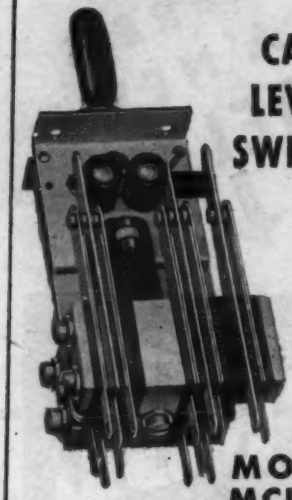
PRICE Brothers Co.

★ ★ ★ ★ FREDERICK, MARYLAND

RELAYS, CONTROLS, AND MAGNETIC DEVICES ★ 30 YEARS EXPERIENCE

Master

CAM LEVER SWITCH



MODEL MCL-FS

The Model MCL-FS is designed for switching applications requiring long life and dependability. Due to its ability to control multiple circuits, it is used by the thousands for electronics and communications equipment. Roller cam action eliminates contact bounce — single bolt secures or releases contact assemblies — contact possibilities are unlimited. If you're thinking of switching, think of the original cam lever switch specialist, General Control Company!

*Single Bolt Assembly.
*Static Shielding.
*No Side Thrust.
*Government approved.
*Mechanically stronger.
*Rating — 10 amps. 125 V. A. C.
— 2 amps. 125 V. D. C.
*Breakdown — 2500 V. Between Springs
—4500 V. Springs to Frame.
*Write for Catalog No. MCL-20.

GENERAL CONTROL COMPANY
1202 SOLDIERS FIELD ROAD
BOSTON 34, MASS.

electrical equipment beyond the limit of thermal stability of conventional organic materials. One of the resins is available as a coating and impregnating varnish which may be applied to Fiberglas cloth, asbestos cloth, asbestos paper and Fiberglas service wire and similar products by conventional dipping and drying methods. It requires baking at a temperature of 250 deg C for one to three hours to cure to a non-tacky state. Another resin is an impregnating varnish which sets with heat at 200 deg C. Neither of these materials carbonize or darken when subjected to prolonged heating at the curing temperatures.

Dow Corning Corp., Midland, Mich.

Revolving Field Generators

KATOLIGHT REVOLVING field generators are built in sizes 5, 10, 15 and 25 kw, 4 pole (1800 rpm). These generators can be furnished as independent two-bearing generators suitable for belt or coupling drive or as single bearing generators designed to fit standard SAE engine

bell housing. They are conservatively rated and will carry 25 percent overload without exceeding allowable temperature rise. Voltage regulation is approximately 10 percent with 2 cycle speed change. Illustrated is Model 49EG04 which is a 10 kw, 110 v a.c. motor.

Kato Engineering Co., Mankato, Minn.

Rectifier

MODEL No. 869B rectifier tube is for use in broadcasting or induction heating equipment. It is designed to withstand rough usage, vibration and high peak-inverse voltages with no arc back. The carbon anode of the unit is a large, heavy-duty type. Protection is provided against loose

A Complete Fungicide treatment for Small Parts...

Wax or Varnish

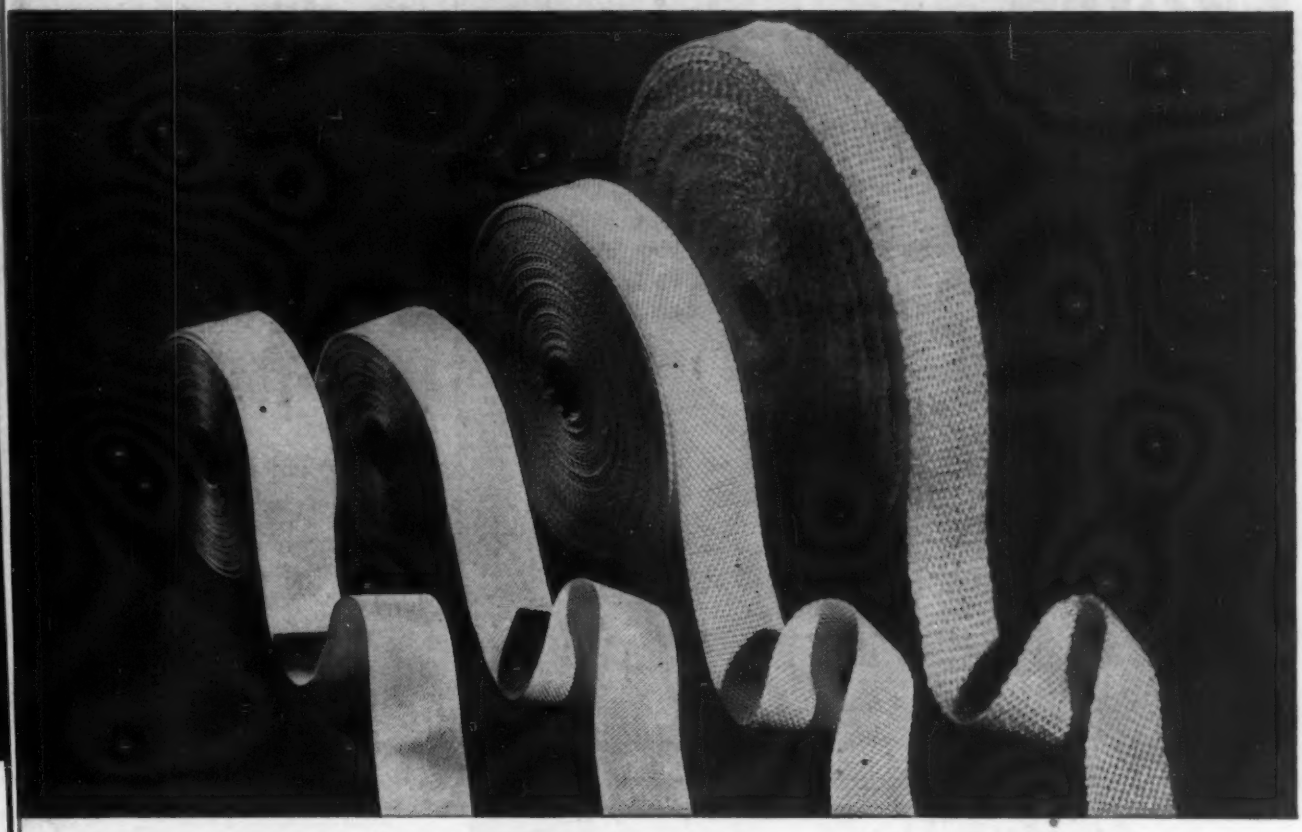
In accordance with government specifications, we can render a FUNGICIDE treatment along with our complete moistureproofing service. Small parts are thoroughly dehydrated for the length of time needed to thoroughly extract moisture. Parts are waxed and varnished according to specifications and all areas are thoroughly coated. Sufficient time is allowed to thoroughly impregnate all materials to the full extent of their porosity. All surplus wax is removed by this operation leaving all machined surfaces and counter bores clean and smooth. All smooth surfaces are polished to a dust-free hard finish.

Daily
PICK-UP AND DELIVERY
in METROPOLITAN AREA

★

PRODUCTION ENGINEERING CORP.
666 VAN HOUTEN AVE.
CLIFTON, N. J.

FIBERGLAS* Electrical Tapes...



. . . inorganic . . . strong . . . wide range of sizes . . . can help solve <u>your</u> electrical insulating problems

Many complicated electrical design and repair problems have been solved by the use of Fiberglas Tapes. One of the many advantages is their availability in a wide range of widths and thicknesses.

Fiberglas Tapes are as thin as .003" and as thick as .015", with intermediate thicknesses of .005", .007" and .010"... Standard widths range from ⅜" to 1½".

But, you can also add to this feature the extraordinary tensile strength of Fiberglas Tape! Fiberglas Tape—½" x *.003"*—has an approximate breaking strength of 80 lbs.! Compare this breaking strength with those of *.007" organic tapes!*

Fiberglas Tapes, being glass, have many properties which make them most desirable for use in the insulating of electrical equipment . . . resistance to high temperatures, moisture, oil, corrosive vapors. In combination with suitable varnishes, the result is longer-lasting and more efficient electrical insulation.

Fiberglas is available in all of the standard untreated forms, together with varnished cloth, mica-Fiberglas combinations, varnished sleeving, pressure-sensitive tapes and Fiberglas laminates.

So, whether you manufacture, service, buy or use electrical equipment—Fiberglas is worth knowing about, in every detail.

Fiberglas electrical insulating materials are now IMMEDIATELY AVAILABLE in quantity from distributors' stocks.

When you write for complete information, include a request for your copy of booklet "What Keeps the Wheels Turning" . . . *Owens-Corning Fiberglas Corporation, 1860 Nicholas Bldg., Toledo 1, Ohio. In Canada, Fiberglas Canada, Ltd., Oshawa, Ontario.*

ARMY E NAVY

FIBERGLAS ...A BASIC MATERIAL

*T. M. Reg. U. S. Pat. Off.

YARNS • TAPES • CORD • SLEEVING • CLOTH AND OTHER FORMS

G. A. W. Carbonyl Iron Powders

Extensive research and manufacturing development has been put back of the various G. A. W. Carbonyl Iron Powders —used by leading core manufacturers. Powders with different characteristics are available for specific radio-electronic applications.

Write for samples and further information.

GENERAL ANILINE WORKS
A division of
General Aniline and Film Corporation
435 Hudson St., New York, N. Y.
Manufacturers and Sole Distributors

Put The "Finger" on *Faulty* INSULATION

By a Mere Press of the Button on the VIBROTEST

Model 201 VIBROTEST

Put the finger on dangerous insulation with the versatile VIBROTEST . . . prevent costly electrical breakdowns before they happen! Just a mere press of a button and the large clear-faced meter tells the story quickly in megohms or ohms.

No hand cranking . . . no leveling . . . no vise-like grip . . . just an easy one man job.

Model 201 VIBROTEST . . . sturdy, compact and easy to use . . . also provides triple AC and DC voltage ranges. Only two terminals. Many VIBROTEST models available to meet other requirements. Write today.

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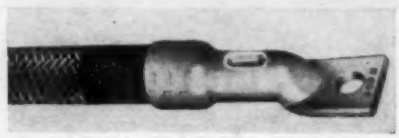
anodes. The cathode shield is made with an edgewise-wound ribbon filament of a new alloy which provides emission reserve and longer life. The tube has the following rated characteristics: Maximum peak-inverse anode current (25–150 cycles) 10 amp; average anode current 2.5 amp (in-phase filament excitation); typical conditions in a single-phase, full-wave circuit (2 tubes); a.c. input voltage 7070 (RMS per tube); d.c. output voltage 6360; maximum d.c. load current 5 amp.

Arpin Mfg. Co., 422 Alden St., Orange, N. J.

Water-Seal Electrical Connectors

CONNECTORS WHICH SEAL cable ends against water are available in several types, some of which include Hysealug for single conductor cables and Hysealinks, Hysealplugs, etc., for cables from No. 4 to 2000 mcm. The connectors are made from pure copper and are silver



plated. The barrel of the connectors is indented onto the conductor while the shroud is compressed over insulation to form a watertight cable end seal.

Burndy Engineering Co., Inc., 107 Eastern Blvd., New York 54, N. Y.

Pilot Light Assembly

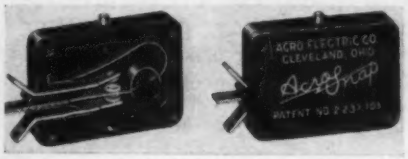
"TRIO-LIGHT" pilot light assembly is a unit designed to aid in the control of multiple co-ordinated circuits. It is available in any size bank, in multiples of three pilot lights to each assembly. The silver plated terminals of the assembly are secured to insure perfect contact under severe stress. The lamp sockets of the pilot lights accommodate bayonet base lamps which are easily removable from the front of the panel. Features of the assem-

bly include color-coded flat lenses with etched numbers, letters or words; choice of lens colors in either red, green, amber, blue, yellow, opal, white or clear; and the use of half-round lenses. The unit may be obtained grounded or ungrounded.

Dial Light Co. of America, Inc., 900 Broadway, New York 3, N. Y.

Snap Switch

MINIAC DESIGNATES a snap-action which measures 11/32 in. high, 1 1/32 in. long, and 1/4 in. thick. It is fully enclosed in a Bakelite case which contains four mounting holes measuring 1/8 inches in diameter. Leaf-type or overtravel-plunger-type actuators may be attached to the case if desirable. Actuation is made by a stainless-steel pin plunger. All

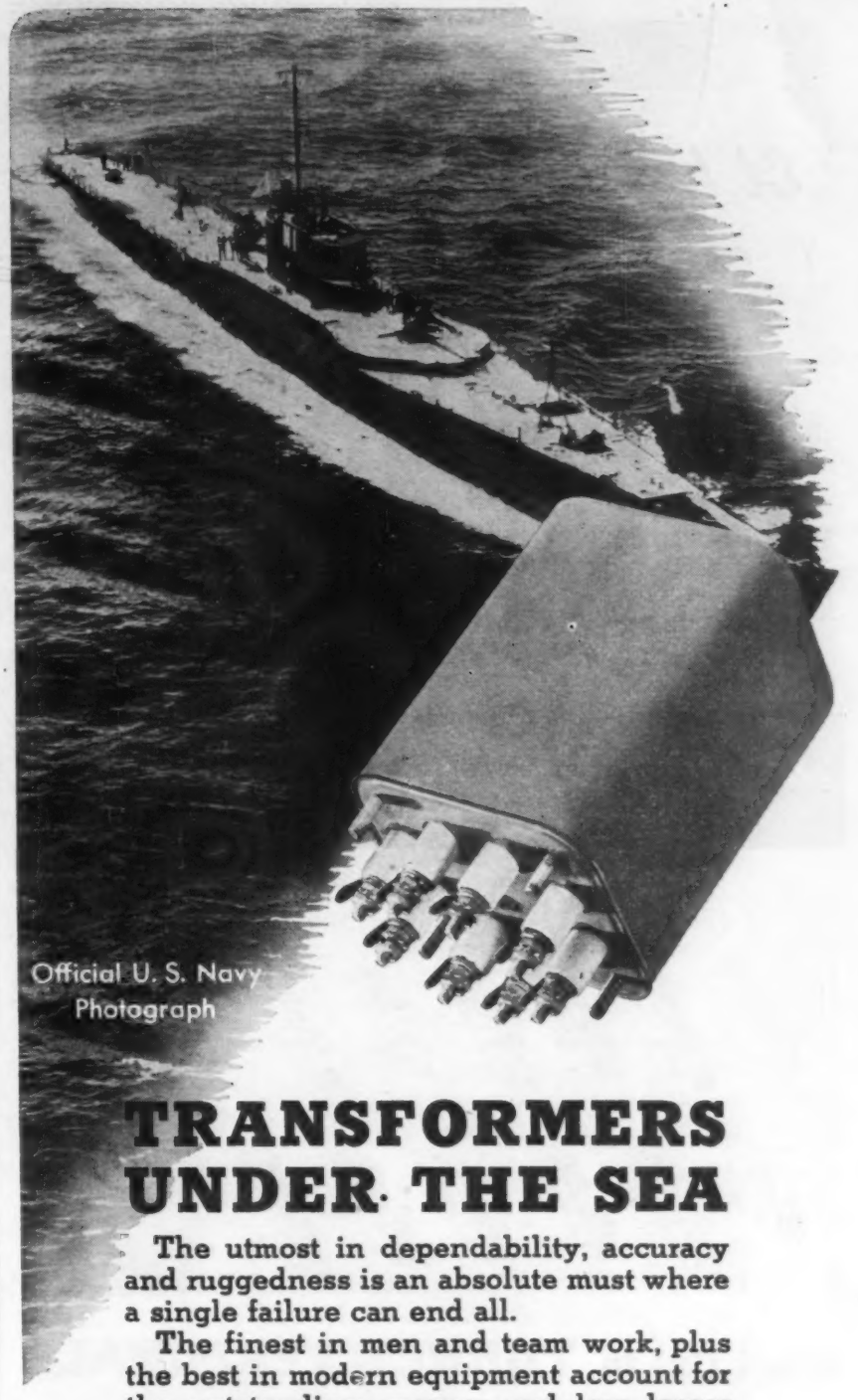


parts of the switch are non-corrosive and all contacts are made of silver. The main and contact blades and rolling spring are made of beryllium copper. The switch is available in SP, normally open, normally closed, and DT types, and is rated at 15 amp, 115 v a.c.

Acro Electric Co., 1316 Superior Ave., Cleveland 14, Ohio.

Rectangular Oil-Type Capacitors

A NEW AND COMPLETE line of rectangular oil-type capacitors (designated as Capacitrons and available in types BC, EC and CC) are available in standard container sizes and in voltage ratings up to 6000 volts d.c. working. These new Capacitrons will meet Army and Navy specifications, including total salt-water submersion tests. Capacities, voltage ratings, container sizes, types of terminals, and mounting arrangements are given in Bulletin No. 104 available from The Capacitron Co., 318 W. Schiller St., Chicago 10, Ill.



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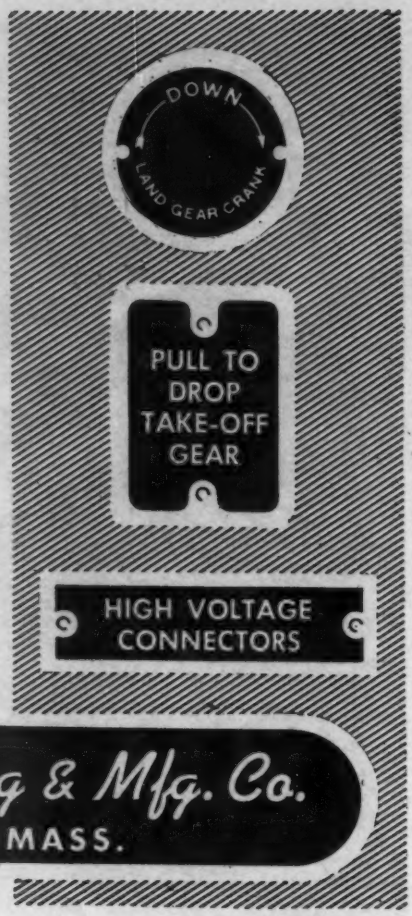

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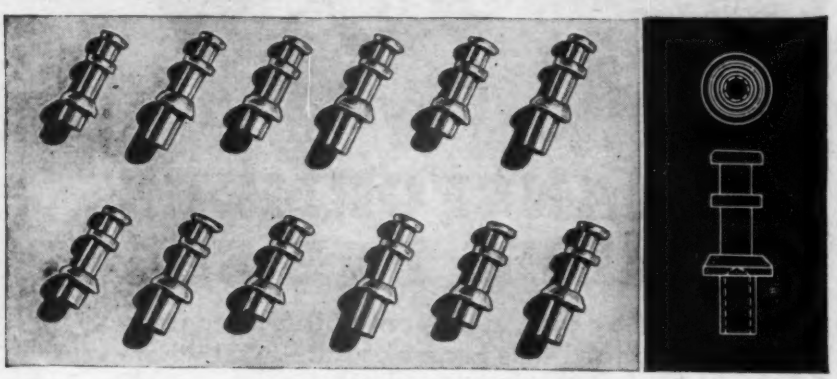

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R. W. Cramer Co., Inc., Centerbrook, Conn.

Literature

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Company Brochure. This booklet tells of the development of Electrical Testing Laboratories, Inc., a company which deals in electrical and general testing, inspections and research of electrical products. The name of the brochure is "Independent Laboratory Services." Electrical Testing Laboratories, Inc., 2 East End Ave. at 79th St., New York 21, N. Y.

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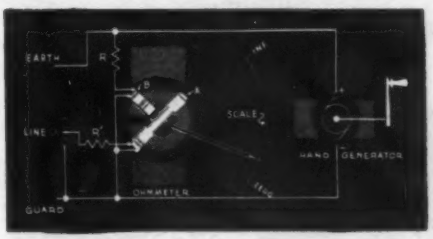

PRINCIPLE OF OPERATION

In what we term a cross-coil true ohmmeter, two coils are mounted in fixed relation to each other on the same pivot-and-jewel moving system in the field of a permanent magnet. "Current" flows in coil A and "potential" in coil B, and they are connected so that their respective torques oppose each other. Since there are no control springs, the opposing coils give a true ratio of E/I, and ohms (or megohms) are indicated directly by a pointer over a scale. The readings are independent of the voltage of the hand-driven d-c generator, because any change in the voltage affects both coils in the same proportion.

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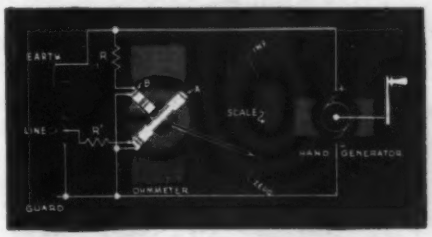

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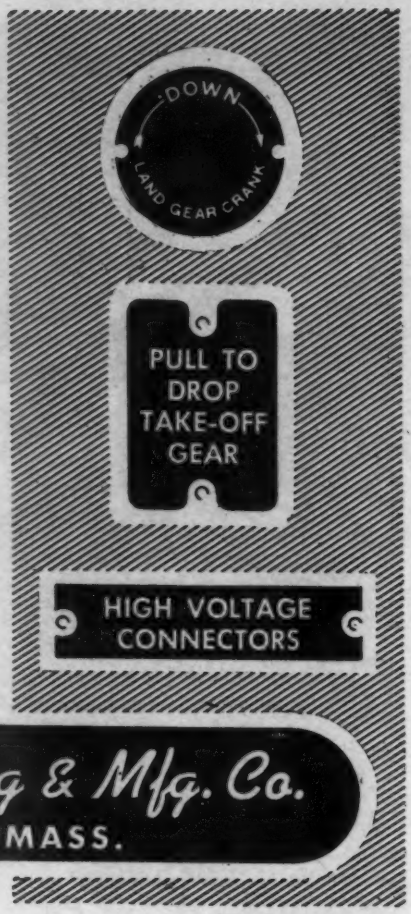

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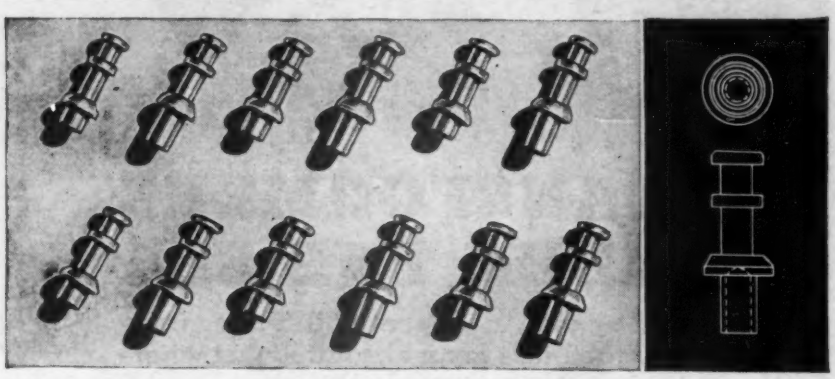

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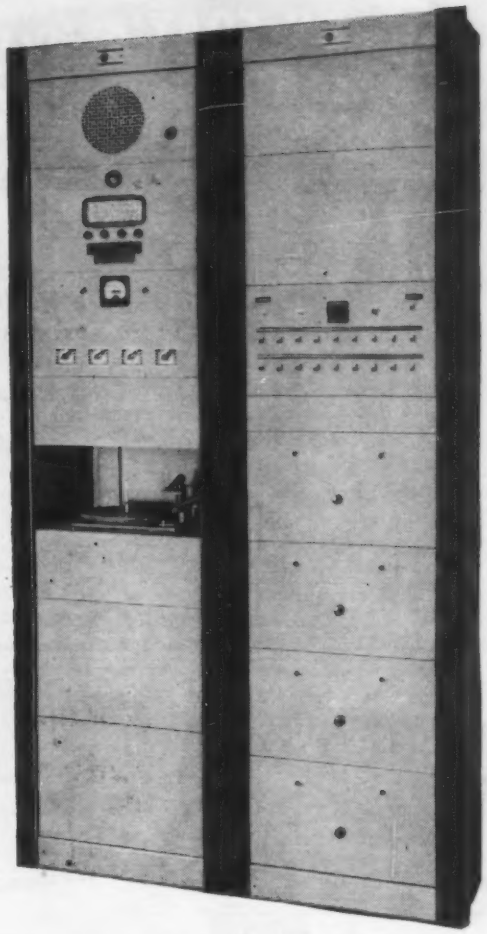

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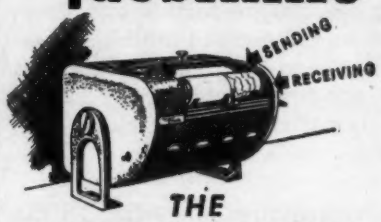

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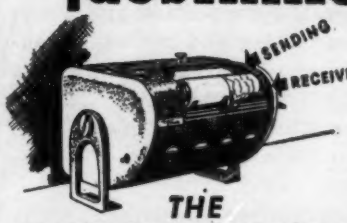

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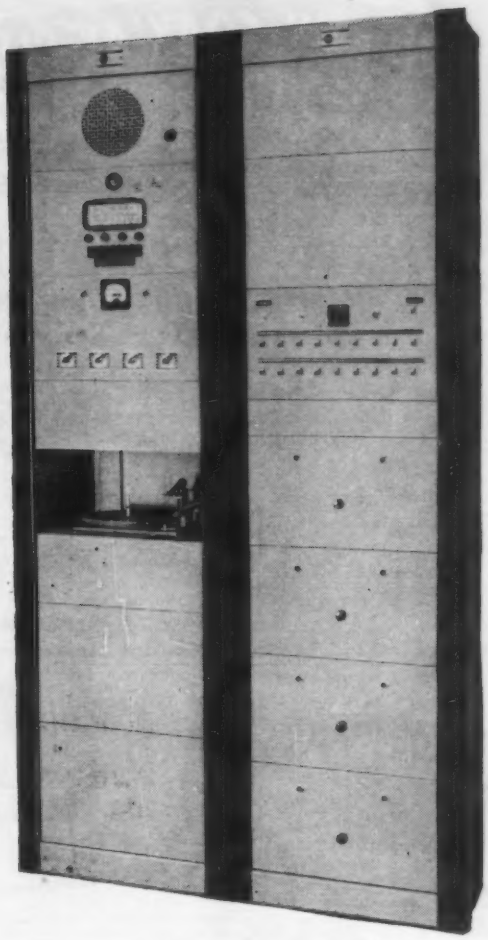

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Machined from brass bar stock, these sturdy plugs and jacks provide a positive connection between the outer conductors and between the inner conductors. Inner conductor contacts are silver plated to obtain maximum conductivity. Insulation is the best grade of Mycalex. Patch cords are made of low-loss flexible coaxial lines of 72 ohms surge impedance. Patch panels consist of 24 jacks mounted on a 19" relay rack panel.

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You don't have to solder through a window to install an ANDREW plug or jack. Just remove one screw, slide the sections apart with your fingers and solder. This is a new improvement invented and used exclusively by ANDREW.

WRITE FOR BULLETIN NO. 31

ANDREW CO.
363 East 75th Street
Chicago 19, Illinois

Illustration shows panel with patch cord in place.

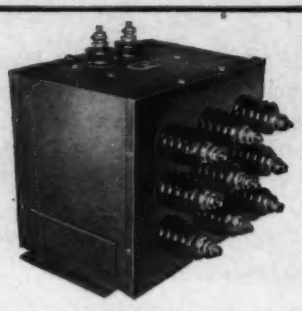
Panel Instruments. Panel instruments with bridge type construction and with soft iron pole pieces are illustrated and described, together with cased models, in a 16-page folder. O. B. McClintock Co., Minneapolis, Minn.

Luminescence. "The ABC of Luminescence" is the title of a 24-page book which tells in simple language the principles of luminescence, and includes a discussion of the practical applications of these principles in the form of activated fluorescent and phosphorescent pigments. A number of simple tables and charts are included to illustrate terms applicable to this particular industry. The New Jersey Zinc Co., 160 Front St., New York 7, N. Y.

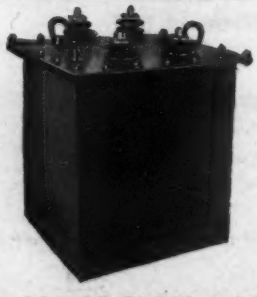
•

SOLDIERS ON GUADALCANAL report that they can receive some American standard broadcast stations with fair regularity.

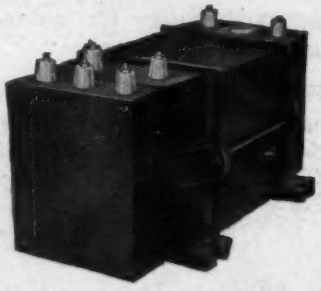
HERMETICALLY SEALED TRANSFORMERS



FILAMENT TRANSFORMERS



OIL-COOLED PLATE SUPPLY TRANSFORMERS



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with KATOLIGHT ROTARY KONVERTERS for operating radio and electronic equipment, moving picture projectors, sound apparatus, A.C. appliances, etc.

225 WATT CONVERTER

Available in sizes 110 through 2500 watts, 1800 and 3600 r.p.m. ball bearing designs. Furnish standard 110-volt 60 cycle A.C. from 32, 110 or 220-volts direct current. Quiet in operation. Can be furnished with special filtering equipment for sentitive radio work.

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At present Kato's entire production must be directed to furnishing converters on high priority orders. Wire us if you need this kind of equipment for orders.

Also manufacturers of A.C. and D.C. generators ranging from 350 watts through 25 K.W.; power plants; Frequency changers; high frequency generators; and Motor Generator Sets.

KATO ENGINEERING CO.
72 ELM ST. MANKATO, MINN.

Carrier Communication

(*Continued from page* 114)

through 0.002-μf, high-voltage, mica capacitors.

Signaling and Control Circuits

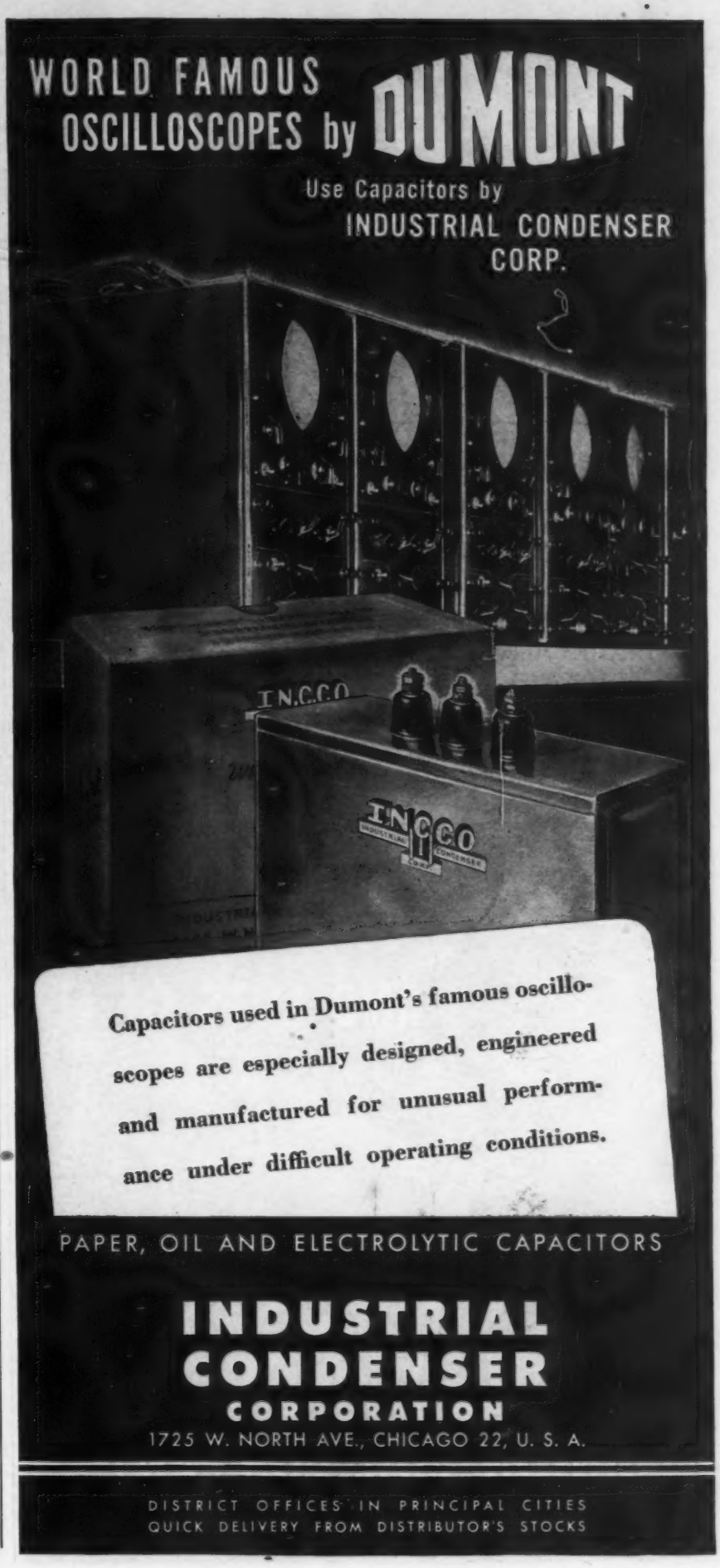
Located on the dispatcher's desk is a speech amplifier including an oscillator to give a 1000-cycle tone. Amplitude of this note is considerably higher than that of the average voice input. This tone is used as an attention signal. It is fed into the amplifier through a momentary contact switch, thus enabling the dispatcher to secure the attention of all crane operators before transmitting orders which might apply to any one of them. The output of this amplifier is fed to the carrier current transmitter via a telephone line which is simplexed. On the amplifier, a "press-to-talk" key completes the circuit through this simplex and actuates a relay in the transmitter—applying plate voltage.

The speech amplifier is duplicated in the transmitter cabinet and by means of a "local-remote" switch can be used instead of the amplifier located on the dispatcher's desk. This allows the transmitter to be modulated when making tests on it.

A time-delay relay is provided so plate voltage cannot be applied simultaneously with filament voltage. This protects mercury vapor rectifier tubes in the event of interruption to the a-c supply voltage. Plate voltage is applied to the transmitter by means of the relay described previously.

Operating Problems

Considerable difficulty has been experienced with the contactor shoes of the cranes. Operation of the receiver while the crane is in motion is not entirely satisfactory; noise produced by the arcing of the shoes on the trolley is sufficiently high to trip the squelch circuit. This results in a continuous sputtering noise, and since the audio output of the receiver is quite high, this is very distracting to the crane operator. Some improvement has been effected by reshaping the con-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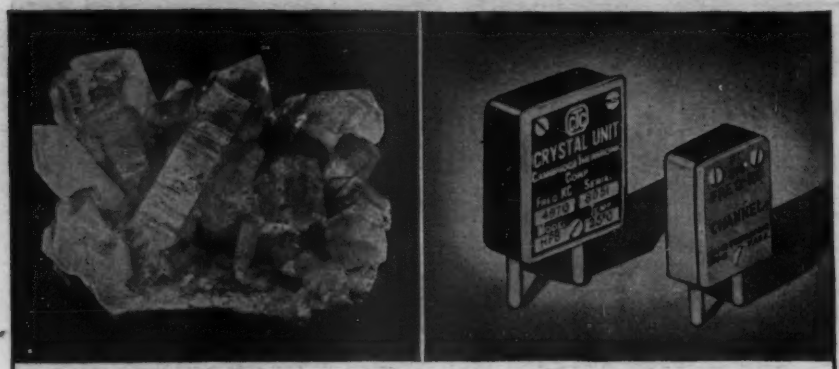

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X-RAY ORIENTATION — predetermination of the crystallographic axes to assure correct cutting . . . Four individual lapping operations, plus edge lapping . . . Soap washes and clear water rinses . . . Filtered compressed air drying . . . insure the constant frequency, high activity and dependability of every C. T. C. Crystal.

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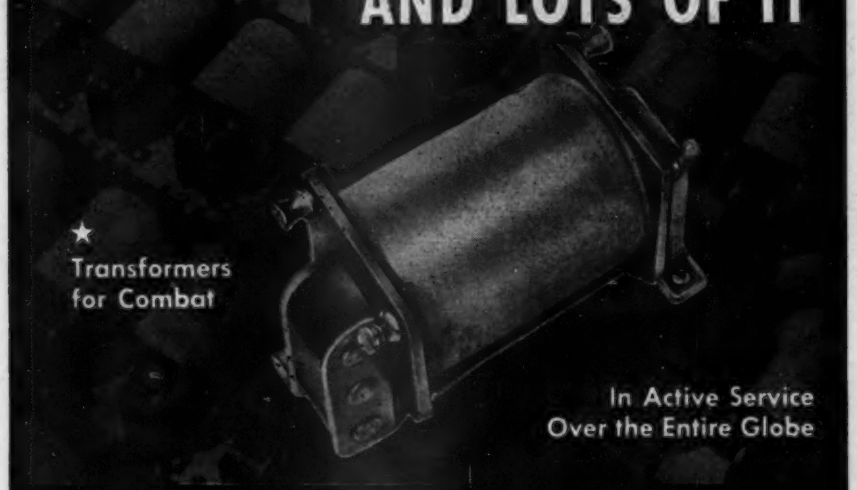
AND LOTS OF IT



★ Transformers for Combat

In Active Service Over the Entire Globe

DINION COIL COMPANY

CALEDONIA, N. Y.

tact shoes and resurfacing portions of the trolley bus throughout the plant.

Located, as it is, in the center of a production area, the dispatcher's desk has an extremely high acoustical noise level and it was found necessary to provide an enclosure so background noise would be reduced during transmission.

The system has been in continuous operation for six months and has already demonstrated its value as a means of speeding production by saving time. Special credit is due R. B. Jones, under whose direction all experimental testing as well as construction work was done.

Tests made outside the plant indicate complete absence of radiation.

Transmitters are now being installed in the crane cabs to provide two-way communication. Experiments indicate that this will increase the utility of the system considerably. Eight cabs are in use at present, with plans being made for the addition of others at an early date.

Lavite **STEATITE CERAMIC**

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Specific gravity of only 2.5 to 2.6
Water absorption S. 1.5-0.001 per cent. Per cent power factor.

S. 1.5 to 60 cycles was only 0.0165.
Dielectric constant at 60 cycles was 5.9-1000 KC 5.4.

Makers of electrical and radio apparatus destined for war service are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot fumes, acids, and high heat. The excedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

We will gladly supply samples for testing.

D. M. STEWARD MFG. COMPANY

Main Office & Works, Chattanooga, Tenn.
New York Needham, Mass. Chicago Los Angeles

28-Volt Operation

(*Continued from page* 119)

tics and minimum tube-to-tube variations. For vhf use, the 9003 should prove very satisfactory.

The types most satisfactory for resistance-coupled voltage amplifiers with 28-volt B supply are pentodes and low-mu triodes. High-mu triodes cannot be used successfully because the bias developed in the grid resistor by the grid contact potential will cause the tubes to operate at or near plate current cut-off. The cut-off bias of a triode is approximately the ratio of plate voltage to mu. For the type 12SQ7, which has a mu of 100, the approximate cut-off bias would be 28/100, or −0.28 volts. Since the bias developed by contact potential in the grid resistor may vary from −0.2 to −1.2 volts, the impracticability of using high-mu triodes is apparent. They will not only produce less amplification than a low-mu triode at 28-volt B supply, but will produce much less maximum voltage output, with large gain variations between tubes of a given type.

28-Volt Amplifier Performance

Data on resistance-coupled audio amplifier gain and maximum output voltage (for 5 percent distortion) are given for triodes in Table II, for three different values of plate load and following grid resistor. Information on transconductance, plate resistance, and mu is also given which will be applicable in the case of transformer or choke-fed amplifier stages. Resistance-coupled amplifier data for several pentodes is presented in Table III. Any of the tubes shown in these tables should prove very satisfactory in 28-volt service, the selection depending on the gain requirements and use of auxiliary diode or triode sections.

It is probable that in the future tubes designed especially for low-voltage applications will be added to the many tube types already available. However, it appears that most of the present standard types will prove satisfactory, and the design of new types for 28-volt service should be limited to tubes for applications in which present standard types are not entirely suitable.

A New Miniature Diffusion Vacuum Pump

Compact.. All-Metal

THE DPI miniature all-metal pump, Type VMF-10, marks an entirely new application of the fractionating, self-conditioning principle for the production of high vacua. The VMF-10 meets the demand of industry for a rugged yet compact pump capable of reaching pressures of 10^{-6} mm. and lower.

This unit was primarily designed for use on electron microscopes, automatic exhaust machines, continuously evacuated tubes, and other industrial applications where an inexpensive miniature metal pump is required. It will be found useful on any system of moderate size. Choice of water or air cooling.

CHARACTERISTICS

SPEED	10 L/sec. at 10^{-4} mm. Hg.
ULTIMATE VACUUM	1 x 10^{-6} mm. Hg. with Octoil-S
REQUIRED FOREPRESSURE	0.125 mm. Hg.
HEIGHT	7¾ in.
WIDTH	3⅞ in.
WEIGHT	2.5 lb.

WRITE for details about this new-style diffusion pump—or similar models with different capacities—as well as 20 other types of diffusion pumps, low-vapor-pressure fluids, greases, vacuum gauges, control circuits, and other items for high-vacuum technology. Address Vacuum Equipment Division.

METAL FRACTIONATING PUMP, TYPE VMF-10 (Water-Cooled)

DP INC. HIGH-VACUUM HEADQUARTERS

DISTILLATION PRODUCTS, INC.

Jointly owned by EASTMAN KODAK COMPANY and GENERAL MILLS, INC.

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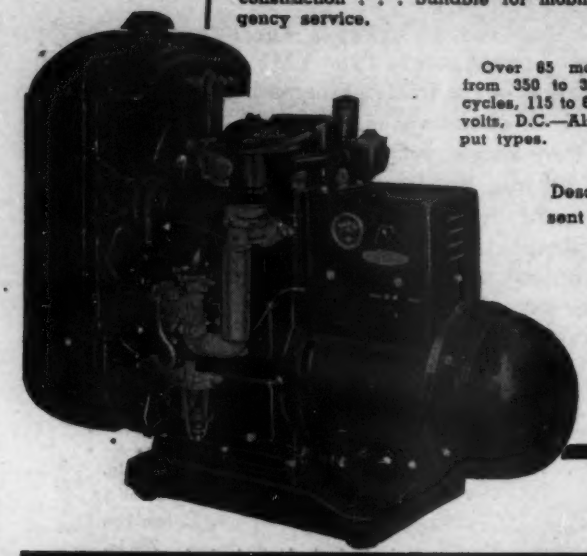

Over 85 models, ranging in sizes from 350 to 35,000 watts, 50 to 800 cycles, 115 to 660 volts, A.C.—6 to 4000 volts, D.C.—Also dual A.C.—D.C. output types.

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Crystal Testing

(*Continued from page* 123)

starting time in a production-type test oscillator over the temperature range. The crystal must reach the minimum acceptable activity within ½ sec.

The full load test consists of operating the crystal at room temperature in a standard test set for a period of not less than 15 sec with the plate circuit of the set tuned to give maximum activity. Crystal activity must pass a certain minimum.

In the vibration test, crystals are mounted by the pins in random directions on the platform of a vibration machine. Units are subjected to a simple harmonic motion of a certain amplitude and frequency and left for two hours. This treatment is intended to simulate the shock and jar that crystals will receive in severe service. At the end of two hours, frequency must not have changed more than 0.002 percent and activity more than 10 percent from the values registered before the tests.

Another test involves immersing

Available from local dealers or by writing factory direct.

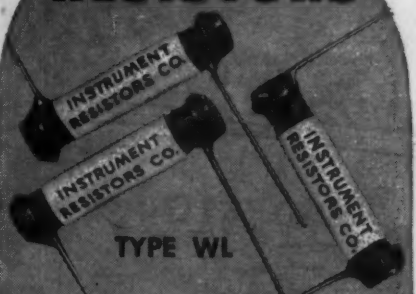
UNIVERSAL STROBOSCOPE

This handy phonograph turntable speed indicator, complete with instructive folder, is now available gratis to all phonograph and recorder owners through their local dealers and jobbers. As a recorder aid the Universal Stroboscope will assist in maintaining pre-war quality of recording and reproducing equipment in true pitch and tempo.

Universal Microphone Co., pioneer manufacturers of microphones and home recording components as well as Professional Recording Studio Equipment, takes this means of rendering a service to the owners of phonograph and recording equipment. After victory is ours—dealer shelves will again stock the many new Universal recording components you have been waiting for.

UNIVERSAL MICROPHONE CO.
INGLEWOOD, CALIFORNIA

IN—RES—CO RESISTORS



TYPE WL

are specialist-wound to solve your

APPLICATION PROBLEMS

Analysis of peace-time requirements indicates a tremendous field for electronic products—and a comparable multitude of production and assembly problems.

The numerous engineering refinements of IN-RES-CO resistors—products of specialized, automatic high-speed winding—are attested to be their wide adoption in communication and control equipment of every description. Type WL, for example, has standard tolerance of 1%, 1 watt rating and a maximum resistance of 15,000 ohms—yet measures only 1" long and 3/16" in diameter.

IN-RES-CO resistor components—meter shunts, multipliers, chokes and solenoids—represent an all-inclusive line. The new 18-page catalog will be sent to you free on request on company letterhead; write today.

INSTRUMENT RESISTORS CO.

IN-RES-CO

25 AMITY STREET
LITTLE FALLS, N. J.

the units in water at room temperature and heating them to 90 deg C during a period of 30 min. The units are held at this temperature for an hour. They are then dried and set aside for 30 min. Frequency must not change more than 0.002 percent, the activity must change less than 10 percent, and the d-c resistance, measured between the prongs, must not be less than 10 megohms.

In the cleaning and internal inspection tests, crystals are disassembled and examined. Crystals are scrubbed with nylon toothbrushes in soap and water. Electrodes and crystal blanks are then rinsed in clear water and dried by evaporation. Units are then reassembled; at no time during the entire procedure are the crystals touched by hand. After this, frequency should not change more than 0.006 percent and activity more than 10 percent.

After satisfactory spot tests, each unit is tested for frequency, activity, and full load at room temperature. Those passing are given the official stamp and are ready for shipment.

Effects of Age

After the rigid inspection and testing procedures through which crystals are run to weed out the bad ones, it would appear that the units should last indefinitely. Yet crystals often go dead on the shelf before they are actually used. These defections are due to a phenomenon called aging. Caused by an action on the surface of the quartz, this phenomenon resembles common erosion.

Under high magnification, the surface of a crystal, although finished with the finest optical powder, is revealed as being covered with microscopic hills and valleys. Traces of moisture within the holder combine with changes in temperature to cause chipping and cracking of these hills. This raises the frequency of the crystal, at the same time usually decreasing activity. This is explained by the fact that chipping decreases the thickness of the crystal—to raise the frequency—at the same time depositing a film of quartz powder in the valleys—to lower activity. Thorough cleaning of a finished crystal seems to lessen aging.

Another solution consists of ac-

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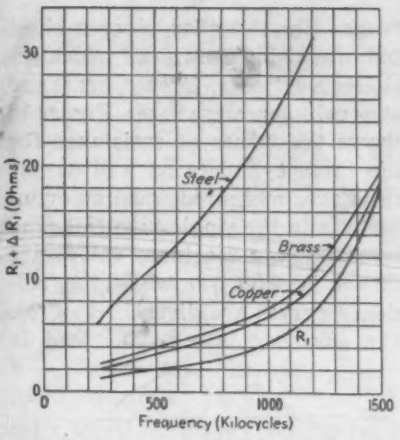

FIG. 18—Input resistance of transformer with copper, brass, and steel loads. The curve marked R_1 is the no-load resistance

dredths of an ohm and reactance values of a few tenths, the resistance looking into the primary of the transformer may be several ohms, while the input reactance may be several hundred ohms.

Measurements of input resistance and reactance as well as efficiency were made on a transformer similar to the one shown in Fig. 17. The primary consisted of thirty-one

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Difficult Places Easy to Solder with specially designed... light but strong, welded construction, precision built KELNOR! "Barrel" of KELNOR 3½" long, ⅝" diameter. 10" overall length. Each of three KELNOR models...65 watts, 100 watts, 125 watts... WEIGHS ONLY 8 OUNCES

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Advantages of **KELNOR** *in* **ELECTRONIC AND RADIO REPAIR FIELDS**

MIDGET RADIOS: In cramped space KELNOR effectively reaches condensers and wiring without danger of burning insulation. Connections at bottom of coils can be soldered from the top, eliminating possibility of melting wax, especially important in the case of oscillator coil.

CHASSIS WORK: KELNOR can be dipped into chassis and turned up at any angle, making those awkward connections without striking edge of chassis. No need to remove top wiring or condensers.

RELAY RACKS: Joints can be soldered from side or back without loosening mounting bolts. KELNOR can reach over top of relay.

Special **KELNOR** *Alloy Extendable, Corrosive-Resistant Tip*

runs completely through center of barrel. Tip can be extended 3⅛" to reach out-of-the-way places.

PENCIL TIP (3/16" x 5¼") for Wire Soldering

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RADIO DIRECTION FINDERS

By Donald S. Bond
Radio Corporation of America

287 pages, 162 illustrations
many charts and tables, $3.00

For all concerned with the design, procurement, or operation of radio direction finders for aircraft, shipboard, or fixed station use, this book will fill a long-existing need for a text and reference covering recent developments, practical systems now in use, and present and future trends in this specialized field.

This book gives:—

—handbook material on accepted methods of direction finder testing

—numerous summaries of data—for example, data on the maximum range of transmission over a wide range of frequencies, in convenient chart form

—tabular summaries of phase shift characteristics of resonant circuits

—schematics and circuit diagrams of commercial equipment and representative equipment of other classifications

The book includes complete sections on the important subjects of wave propagation, directive antenna systems, aural null direction finders, performance characteristics of loop input circuits, visual direction finders and radio navigation aids—any one of which alone would be a sought-after and useful reference.

• Particular attention is paid to the use of ultra-high frequencies, the better understanding of Adcock Systems, the employment of visual direction finders, and such other topics as have been required for improving military and peace-time direction finder systems.

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Three Modern Units for Use With the Most Readily Obtainable Lamp Bulbs

Type No. 590 D/E Unit for use with the S6 candelabra screw base lamp on voltages up to 120 volts.

The No. 590 D/E Unit, List Price, (less lamp) $1.25.

Specifications: Mounting hole, ¾" diameter overall depth, behind the front of the panel 2"; length of threaded area 1 7/16". Underwriters' Approved.

THE NO. 555 D/E UNIT FOR USE WITH THE STANDARD DOUBLE-CONTACT BAYONET BASE LAMPS, TYPE G6 ON LOW VOLTAGES, TYPE S6 ON 120 VOLTS.

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THE TYPE T3 D/E UNIT FOR USE WITH THE T3¼ SINGLE CONTACT MINIATURE BAYONET BASE LAMP BULB.

The T3 D/E Unit, List Price, (less lamp) $1.80.

Specifications: Mounting hole 11/16" diameter; overall depth behind the front of the panel 1"; length of threaded area 7/16"; (our SCB type socket).

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celerated aging by subjecting crystals to a series of hot and cold cycles. If the temperature treatment and a very thorough cleaning are combined, further aging is very slight. The effect is also materially reduced by using an evacuated holder or placing a chemical inside the holder to absorb moisture.

Another recent attempt to prevent aging involved coating the surface of the crystal with water glass which sets to a silicate chemically similar to quartz. This fills up all the valleys and excludes air and water vapor. However, it has been found that the material flaked off after standing several months.

One way to preventing aging is to plate the surface of the crystal with such a metal as gold or silver. This coating, at the same time, can be used as electrodes for the crystal and has promising possibilities. The only difficulty appears to be that tarnish appears on the metal. If this difficulty is overcome, perhaps all future crystals will be plated.

REFERENCES

(1) Elbl, L. A., Quartz Crystal Cuts, ELECTRONICS, July 1943.
(2) Elbl, L. A., Quartz Crystal Finishing, ELECTRONICS, January 1944.

• • •

Induction Heating

(*Continued from page* 129)

the terminals of the coil. Values of current and voltage for an operating power of 100,000 watts are also shown in this table. The current is far in excess of the values of tank circuit current that may be obtained so that it is virtually impossible to place this coil directly in the tank circuit.

Output Transformer

A transformer that has been extremely useful in working into low-impedance loads of the type being considered here is pictured in Fig. 17. This transformer consists of a multi-turn primary which is part of the tank circuit and a single-turn secondary which is really a sheet of copper wrapped around the primary with as close a spacing to the primary as is consistent with voltage requirements. Where the single-turn coil presents resistance values of the order of a few hun-

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- 1 megohm to 100,000 megohms. Multiplier ranges of 1, 10, 100 and 1,000.
- Balanced tube circuit and voltage regulators in internal power supply assure stability.
- Internal checking standard enables operator to check and adjust calibration at any time.
- Broad scale meter dial. Wider than usual spacing at high end.
- One megohm maximum resistance in series with condenser or insulation under test. Assures practically constant voltage across test terminals. Minimized tube-ground current effect.
- Extra charging terminals provided for charging condensers prior to test.
- Sloping panel for bench use. Overall size: 15" x 8" x 10" high.

• Type L Megohm Meter is designed particularly for high-speed testing of condenser leakage resistance, insulation resistance, and insulation measurements generally. Primarily a production-test instrument. Equally handy in the laboratory, factory. Operates on usual AC supply, or with external battery voltage up to 1000. Typically an "Industrial Instrument".

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very good, while the efficiencies with copper and brass loads approach the maximum values that may be expected. The dropping off in efficiency at the higher frequencies is due to resonance effects in the transformer, brought about by distributed capacitance. The efficiency at the higher frequencies can be improved by the proper change in the design of the transformer. However, there is really very little need for this redesign because of the fact that in most metal heating applications there is no point in using frequencies higher than a few hundred kilocycles.

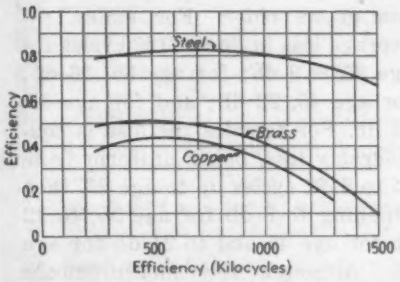

FIG. 20—Efficiency of coupling to copper, brass, and steel by means of a transformer

In conclusion, it may be well to restate that while the simplifying assumptions made in this paper show that the efficiency of coupling to metal loads is independent of frequency, factors such as distributed capacitance come into play at the higher frequencies. At the lower frequencies, the skin thickness may be of the same order of magnitude as the dimensions of the object to be heated, with a consequent sharp reduction in efficiency. This latter effect is partially explained by a consideration of Eq. (6) and Fig. 2.

• • •

High Fidelity

(*Continued from page* 131)

contributed by the air itself, at usual values of relative humidity, becomes of increasing importance. At 10,000 cycles and a relative humidity of 50 percent, the absorption of the air limits the reverberation time to about 1.5 seconds even though the walls, floor and ceiling are perfectly reflective; at 12,000 cycles the limit is approximately 1.2 seconds and at 15,000 cycles

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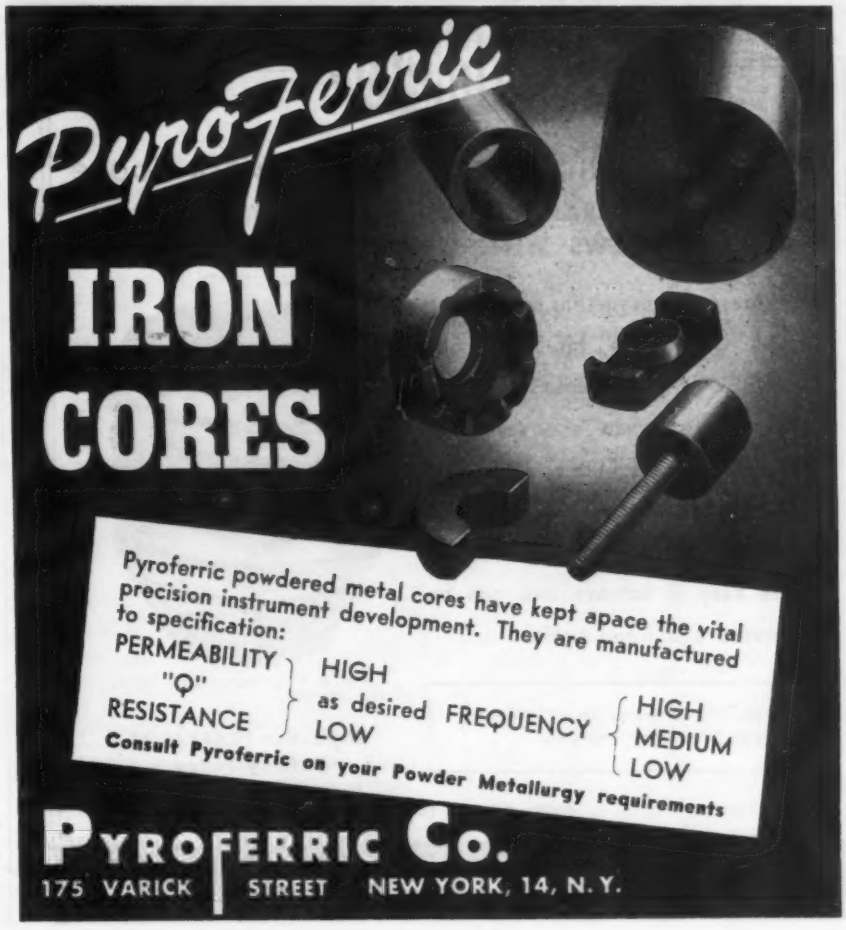

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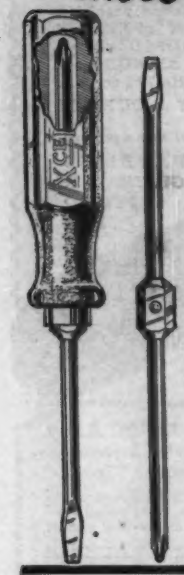

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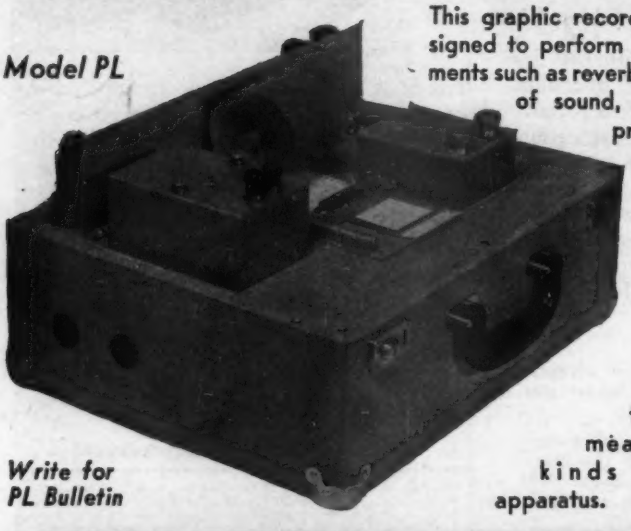

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turns. The secondary copper sheet fed into a single-turn coil which encircled a cylinder. Copper, brass and steel cylinders were used. Figure 18 shows the values of resistance for the three cylinders as well as the resistance measured when no cylinder was in the single-turn coil. The accompanying reactance values are shown in Fig. 19, while the efficiency curves are given in Fig. 20. The efficiency into a steel load is

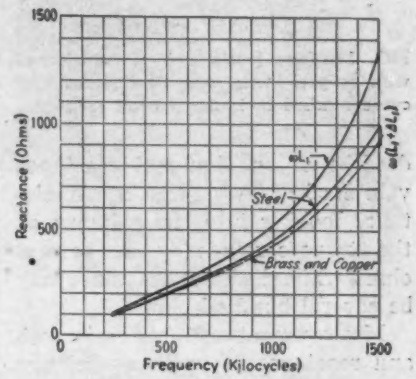

FIG. 19—Input reactance of transformer with copper, brass, and steel loads. The curve marked ωL_1 is the no-load reactance

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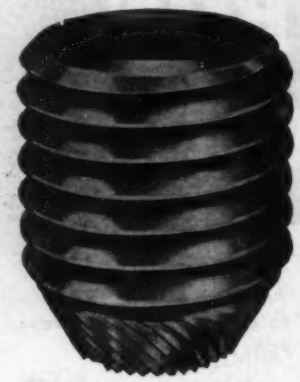

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about 0.9 second. This factor should not be overlooked as it is one relatively fixed limit which certainly must affect consideration of higher fidelity, not only in the studio but also in the home.

Frequency, Loudness and Hearing

The ear, the final criterion of judgment, is also to be taken into account, as the higher frequencies can only be detected by relatively young listeners, since hearing loss at the higher frequencies increases with age. Results obtained by the U. S. Public Health Service in this field (in Bulletin No. 5, 1938) show that above about 2,000 cycles, hearing loss increases rapidly as a person grows older. For males, the average loss in db at 8192 cycles for age 25 is 9 db; for age 35, 16 db; for age 45, 22 db; and for age 55, 32 db. For females the loss is considerably less, being uniform from 64 to 8192 cycles up to age 25, then dropping to 8 db for age 35, to 12 db for age 45 and to 21 db for age 55. Although few measurements have ever been made above 10,000

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cycles, indications are that the hearing loss curves do not trend upward!

Program fidelity is also determined by the loudness level at which the loudspeaker is operated. Curves in Fig. 2 show the frequency response of normal ears at four listening levels, "normal" ears being those of young people about 20 years of age. Note that only at the "very loud" and "loud" listening levels, 100 db and 80 db above the hearing threshold, respectively, is the low-frequency response of the ear substantially flat. The decreased response of the ear at 50 cycles, 100 cycles and 200 cycles, as compared with 1,000 cycles, is tabulated below for four db levels above the threshold of hearing:

	Frequency (cycles per second)			
Condition	50	100	200	1,000
Very Loud (100db)	0	0	0	0
Loud (80db)	−6	−2	0	0
Moderate (60db)	−17	−11	−6	0
Very Soft (40db)	−30	−22	−12	0

In the case of the "very soft" listening condition the response would further tend to be obscured at the low frequencies by local airborne noises as this listening level compares with average residential noise. Any decrease of more than 10 db or so below this level will generally be obscured or masked by said noise. The response of a young listener seated at 45 deg from a radio receiver having a reasonably

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uniform response up to about 10,000 cycles, operated at a loudness level of 60 db which is a "moderate" listening level, shows at 9000 cycles a drop of 42 db from the peak response occurring at about 450 cycles. In the bass direction, the drop-off in response increases gradually from this peak to a value of 26 db down at 40 cycles.

Thus it is apparent that the higher-fidelity receiver should include compensation for listening level effects in the volume control used with the receiver to provide uniform loudness at low frequencies. This device could also be used to compensate partially for the directivity curve of the loudspeaker, where adequate distribution cannot be attained in loudspeaker design. As volume is lowered, such a tone-compensated volume control will then discriminate against the middle frequencies in favor of the low frequencies and, to a lesser degree, the higher frequencies. The effect to the ear will be more pleasing reproduction at the usual listening levels, which are commonly in the "moderate" classification.

Other Distortion Factors

The preponderant majority of sound systems are now, and will be for years to come as far as can now be visualized, mon-aural systems, whether they are utilized for recordings or for radio broadcasting. This fact alone indicates a fundamental departure from perfection because of the absence of true space consciousness of the sound sources.

Some other factors occurring in the general high-fidelity problem, such as random noise and distortion, may also be mentioned. Since distortion components are multiples of fundamental frequencies, and since many audio devices, particularly recordings, have varying degrees of inherent distortion, difficult to eliminate, a wider band will increase the effect of same. This causes much of the upper-frequency "fuzziness" generally in evidence on most attempts at wide-band reproduction. The phase distortion introduced by most sound systems is not believed to be a serious problem, as the ear is apparently not sensitive to moderate phase changes. The phase characteristics should, however, be uni-

form. Distortion must be kept to the lowest possible value and more attention should be directed to investigation and elimination of cross-modulation products as compared with present stress on the more simple harmonic distortion effects.

Multi-path effects resulting in distortion are observable in reception on both amplitude and frequency-modulation systems. This form of distortion, when it occurs, can be more noticeable with frequency modulation, and this effect has been observed in certain instances. It is possible that some listeners will be subject to this distortion, the effects of which increase with an extension of the audio range and deviation. However, good limiting in a frequency-modulation receiver should minimize this form of distortion.

Random noise is directly proportional to band width and any increase in the latter will increase the amount of noise passed. This imposes stringent design conditions on all the units in the line-up and would be particularly difficult to get and to maintain, at a reasonable price, in the case of a practical home receiver.

Standard radio broadcasting is at present limited to an upper modulation frequency of 5,000 cycles as a result of the 10,000-cycle spacing of radio channels, but most

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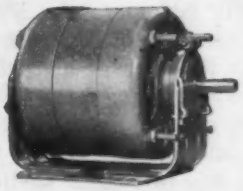

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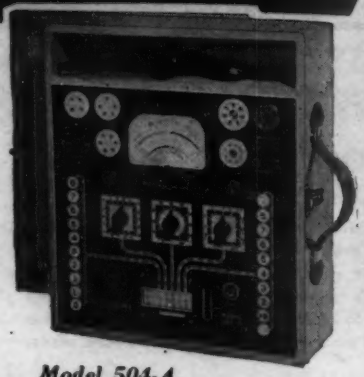

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studio equipment and transmitters are capable of transmitting up to 10,000 cycles or higher. However, satisfactory reception with this wide band is not generally possible in the evening because of "monkey chatter" from adjacent-channel stations, so that a restriction in frequency response in the receiver is in such case actually desirable.

Whether or not we can make full use of a complete audio spectrum depends, in the final analysis, upon the ability of the manufacturers to provide receivers which will satisfactorily reproduce the lower frequencies. Only when this is possible in the average marketable receiver can we make full use of the higher portions of the frequency spectrum and can refer to the system as one of higher fidelity. The average price of a broadcast receiver in 1940, of which many millions were sold, was about $35, and at this price satisfactory reproduction of 50 to 15,000 cycles is not to be expected. It must be stressed that power-handling facilities in all models were quite limited at the lower frequencies due to loudspeaker design, so that the lower limits indicated in Fig. 1 do not actually have the full meaning implied.

Recommendations

In an appeal to common sense and practicability in the matter of fixing an audio band width for receiver it is suggested that the range, from 60 to 8,000, or possibly 50 to 10,000 cycles be considered for all types of broadcasting, including frequency modulation. There is little question, in the opinion of those who have devoted their lives to the problems of sound reproduction, that good reproduction over a practical band will provide a better service to the listener than one of controversial and indefinite quality over a theoretically complete audio spectrum. Our efforts should be directed towards the provision of a balanced system of reproduction as fine as we can possibly design and build it, rather than solely toward extending the upper frequency limits beyond 10,000 cycles with the possible neglect of other more important factors. It is especially stressed that reproduction at the lower frequencies be investigated and improved, because it is in this

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direction, the direction of balance as compared with present trends, that we can best provide what unbiased observation and listeners' preference demands.

How can publicizing and creating a demand for 15,000-cycle receivers or systems be possibly justified, when a good 10,000-cycle receiver that can be made available to the greater part of the public has not yet been designed? For the sake of technical integrity and the future of the radio industry let's get down to earth in the matter of high fidelity. We are faced with the prospect of a post-war era in which it is very likely that many claims for new materials, techniques and overall improvements will face the spotlight of public test—and fail. Let us not, therefore, in our enthusiasm make claims that are too difficult, if not impossible, to realize.

Acknowledgement. Appreciation is expressed for the cooperation of the following NBC engineers in the preparation of this paper: G. M. Nixon, Assistant Development Engineer and C. A. Rackey, Audio-Video Facilities Engineer.

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Transients

(*Continued from page* 139)

age can be expressed as a sinusoidal voltage which is the sum of the three sinusoidal voltages across the circuit elements. Therefore the shapes of the current and voltage waves are identical, except for the amplitude and a phase displacement indicated by the j terms.

Since the instantaneous value of the impressed voltage varies sinusoidally with time and has a phase displacement (which we shall designate as ϕ), the impressed voltage may be written as

$$e = E_m \sin(\omega t + \phi) \qquad (17)$$

where E_m is the maximum or amplitude value. Comparing Eq. (16) with Eq. (17) it is evident that

$$E_m = \left(j\omega L + R - j\frac{1}{\omega C}\right) I_m \qquad (18)$$

Each of these component voltages can be considered to be generated by means of a rotating vector, all vectors of which rotate at the same angular velocity. By means of such a vector diagram, it is easy to show that

$$\phi = \tan^{-1} \frac{\left(\omega L - \frac{1}{\omega C}\right)}{R} \qquad (19)$$

Graphical Representation of Wave Forms

The curves of Fig. 4 represent the current and voltage of a series circuit with sinusoidal current flowing through it. Curve A represents the current which flows through the circuit. Curve B represents the voltage across the resistor R. Curve C represents the voltage across inductance L, and curve D represents the voltage across capacitor C. The voltage impressed across a series circuit consisting only of R and L in which the sinusoidal current, i, flows is shown at E, while curve F represents the voltage across a series circuit consisting only of R and C. Curve G represents the idealized case in which there is no resistance in a series circuit consisting of L and C. Curve H represents the voltage impressed across R, L, and C through which a sinusoidal current flows. By means of the graphical addition employed in deriving curves D to H, the dependence upon the magnitude of the circuit constants of shift in phase between impressed voltage

and current may be easily visualized.

The curves of Fig. 4 provide visual indication that for linear circuits in which the current is sinusoidal, the voltage drops and the applied voltage have the same general form as that of the current. Similarity of wave forms results from the peculiar property of sine waves which makes their derivative and integral of the same shape as the given sine wave, except for phase displacements. This state of affairs, which greatly simplifies the study of alternating current theory, does not exist in general. If waves of other shape had been employed, this state of affairs would not exist.

Graphics for Non-Sinusoidal Waves

There is no end to the variety of wave shapes which might be treated, but there is little need to analyze more than a few simple and typical wave forms in order to illustrate the essential behavior of circuits with non-sinusoidal wave forms. Accordingly, discussion will be limited to a graphical treatment

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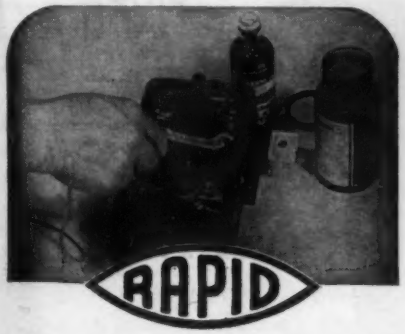

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of square waves, triangular waves, saw-tooth waves, trapezoidal waves and exponential waves, as well as the sine waves which have already been treated. The analysis of the exponential wave is included because it is the only wave variation in which all voltage and current wave forms are identical, except for scale factor. There is not even a phase shift, as in the case of sine waves. Because of this remarkable condition, exponential functions are of great theoretical and practical importance, and much use will be made of exponential functions when transients are treated.

Square Waves

Next consider the case in which the current flowing through a series circuit may be represented by a square wave as shown in Fig. 5. In this and all following cases, the original curve will be differentiated and integrated by graphical methods alone. Curve A of Fig. 5 represents the current flowing in a series circuit, while curve B represents the voltage across a resistor in

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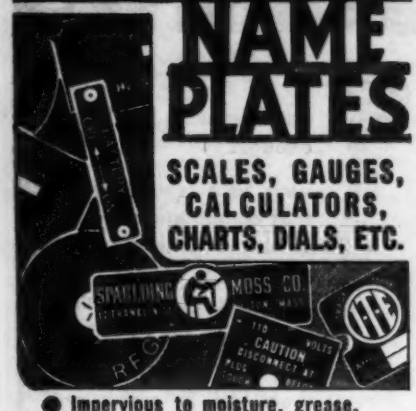

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which the current flows. To obtain the voltage across an inductor, curve A of Fig. 5 must be differentiated (that is, its slope at all points must be ascertained) and the result multiplied by L.

The slope of curve A is zero at all points except the points of transition. At these points the slope is theoretically infinite if the sides of the original wave shape are truly vertical. In practice, the slope has a finite value and is so indicated in curve C of Fig. 5. Curve C represents the voltage across an inductor through which a square-wave current flows. Curve D represents the voltage across a capacitor C through which the square wave of current flows and is therefore proportional to the area under curve A. Note that the wave shapes of curves C and D do not resemble that of the original curve A, nor do they resemble one another.

In order that a square-wave current may flow through the circuit, the wave form of the applied voltage will now depend upon the configuration of the circuit network. If the series circuit is composed of resistance and inductance, curve E (which is the sum of waves B and C) represents the wave form of the voltage required to produce the required square wave of current. Likewise curve F is the voltage required to produce a square wave of current in an RC circuit. If the circuit consists only of inductance, L, and capacitance, C, the required voltage wave shape is given by the sum of curves C and D, shown as curve G. The curve at H represents the voltage wave required in an RLC circuit to produce a square wave of current, but the type of time variation will be as indicated. This example tends to illustrate one very important point. Whereas a harmonically varying current is produced by an applied voltage which is also harmonically varying, identity of voltage and current wave forms does not exist in general. It is for this reason that attention must be given to the wave forms of a number of more important elementary circuits and current wave shape.

Trapezoidal Waves

If we assume that the current wave shape is trapezoidal, as shown in curve A of Fig. 6, then the volt-

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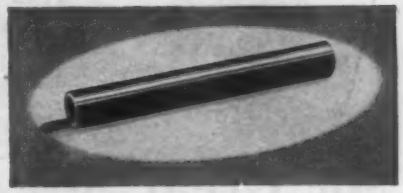

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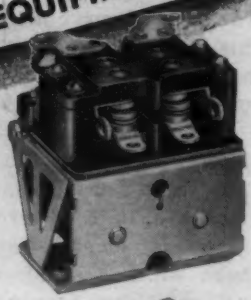

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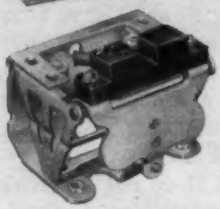

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age across a resistor will take the form shown in curve B. The voltage across an inductance in which a trapezoidal current flows is composed of interrupted rectangular pulses as shown at curve C. A trapezoidal current flowing through a resistor will give rise to the symmetrical but somewhat jagged wave form shown in curve D.

As before, we may add the voltages in curves B, C, and D to determine the required voltage impressed across various types of simple series circuits in order to produce a trapezoidal wave form of current. Curve E represents the required voltage for an *RL* circuit, curve F represents that for an *RC* circuit, and the required voltage impressed across a circuit consisting of inductance and capacitance without resistance (an ideal case) is represented by curve G. If all three circuit elements are present, the required voltage wave form is shown at H. Curve H represents the voltage across an *RLC* series circuit in which a trapezoidal wave form of current flows. Again, none of the

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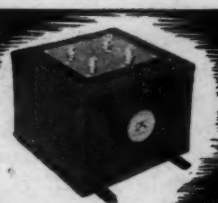

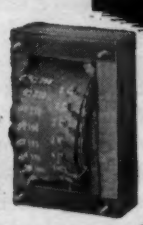

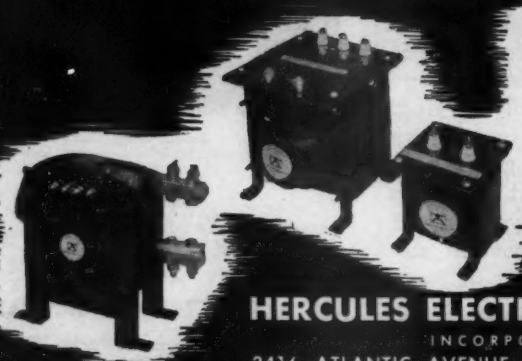

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voltage wave forms resemble the wave form of the current.

Similar reasoning may be applied to the other wave shapes in Fig. 7, 8, and 9. In each case, the analysis is similar to that already developed and no new fundamental concepts are required.

Exponential Function

As shown in Fig. 9, an interesting special case is obtained if the original wave form is part of an exponential function. This is the only function which is (except for the scale factor) identical in form with its derivative and also its integral. Because of this fact, all voltage waves have the same general shape as that of the current. Therefore curves of the same general shape are obtained no matter whether we measure the voltage applied to the circuit as a whole, the voltage across any combination of elements, or the current flowing through the circuit.

The method employed in this elementary analysis may, of course, be extended to other types of wave shapes. It is believed, however, that a sufficient number of examples has been given to illustrate some of the more fundamental physical steady-state concepts encountered when dealing with linear electric circuits having non-sinusoidal wave forms.

Although the graphical methods have been explained in terms of series circuits in which a current of known wave form flows, the analysis is equally applicable, through the principle of duality, to parallel circuits to which a known voltage wave form is applied. In this case curves marked A represent the impressed voltage, while curves B, C, and D represent the currents in *R*, *C*, and *L* branches respectively. Curves E, F, and G then represent the total current taken from the generator for parallel *RC*, *RL*, and *LC* circuits, respectively. The current for a circuit composed of ideal *R*, *L*, and *C* elements in parallel is shown in curve *H*. These results are true, in each case, for the different wave forms shown in Fig. 4 to 9.

Formation of Non-Sinusoidal Recurrent Waves

We have seen that the steady-state responses of linear electric circuits to non-sinusoidal wave

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forms are more difficult to express than those in which the wave forms are sine or cosine waves. Furthermore, while we have simple trigonometric expressions which enable us to express the sinusoidal time variation of a voltage or current with great simplicity and ease, we have, in general, no equally satisfactory method of obtaining analytical expressions for non-sinusoidal wave forms. It has been possible to show these wave forms graphically, of course. However, if we wish an analytical expression for those wave forms, it will be necessary to break each wave form down into its fundamental, recurrent cycles. In some cases (as in all of those selected for treatment here, except the wave of Fig. 3 which does not include a complete period or cycle) it is possible to break down the wave still further, expressing each segment as a single-valued continuous function of time. Several expressions, one for each segment, will then be required to specify the wave, and we must find some means of expressing the fact that these wave segments recur at cycle intervals. With this procedure, the problem is always messy, lacks generality, and is difficult of application.

It can be shown (see any text on Fourier series) that any recurrent wave form can be expressed as a series of simple sine waves of appropriate amplitude, frequency, and phase. Hence, it is possible to build up any of the recurrent waves shown here (among others) by means of sine waves which, we found, were the simplest to handle. The manner in which saw-tooth and square waves may be constructed of a series of sine waves is illustrated in Fig. 10.

Frequently a non-sinusoidal wave form requires an infinite number of sinusoidally varying terms to express the desired wave shape exactly. But sufficiently good approximations to the desired wave shape may also usually be obtained with a finite number of terms since the terms of higher harmonics usually have small amplitude and consequently make little contribution to the wave shapes. Hence, by including a sufficient number of terms, we can approach the desired wave form as closely as we like. The frequency of the last term retained in the

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We may summarize the important conclusions as follows:

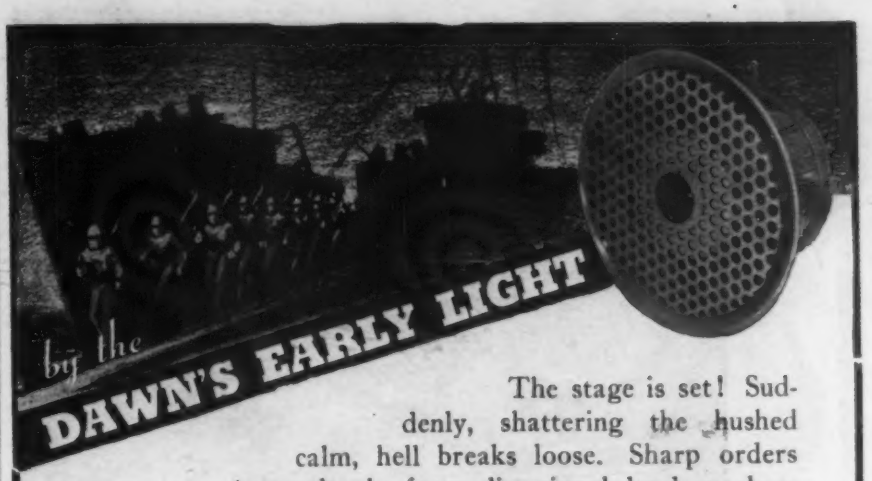
1. For linear circuit elements, the fundamental voltage-current relations (given in Table I) are the general ones employed when dealing with transient or non-sinusoidal steady-state wave forms.

2. In general, the wave forms of steady-state voltages and currents in linear electric circuits do not resemble one another, except that all have the same period or time interval of periodic variation.

3. For the special case of sinusoidal waves, the general derivatives and integrals of Table I are replaceable by terms involving $j\omega$.

4. For the special case of exponential wave form, all voltage and current forms are alike.

5. The graphical methods used in this article have aimed to provide a basis for understanding the fundamental phenomena, rather than for obtaining numerical values of current and voltage.



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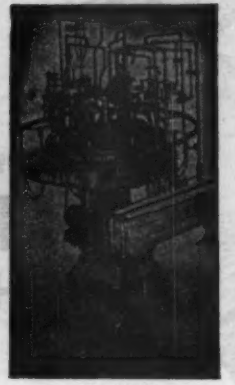

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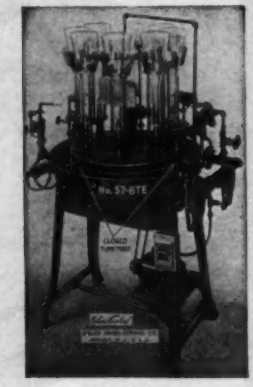

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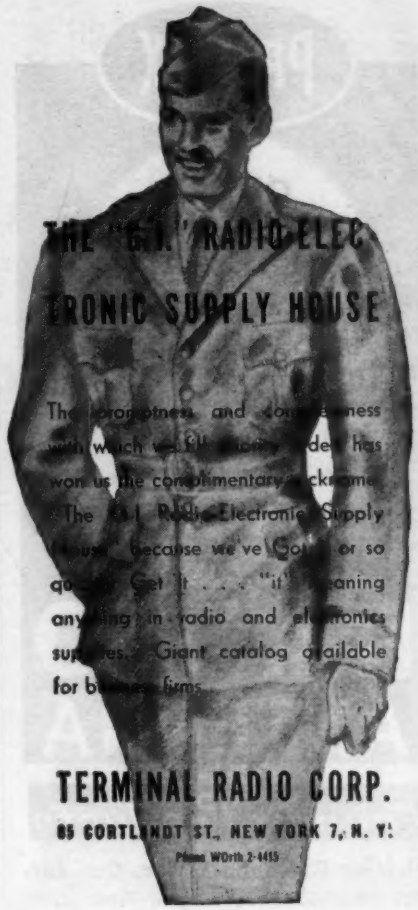
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The first five job sheets cover soldering, wiring, chassis drilling, use of circuit symbols, checking continuity and replacing defective parts. The next five deal with magnetism. No. 11 covers laws of electric charges; three are on fundamental measurements and three more on measuring instruments, while two deal with Ohm's law. Induced currents and the transformer

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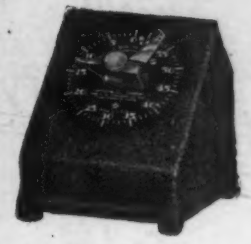

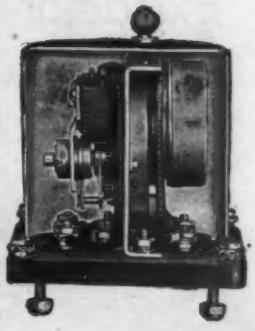

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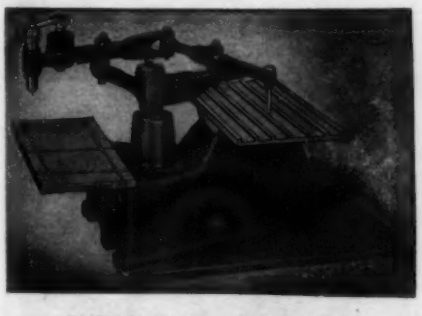

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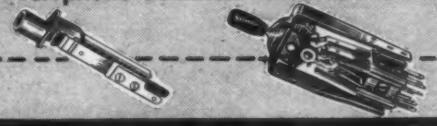

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• • •

Fundamentals of Radio Communications

BY AUSTIN R. FREY, *Lehigh University, Longmans Green & Co., New York, 393 pages, $4.00, 1944.*

THIS SMALL, compact volume, intended to "present in as concise a form as possible, the fundamental principles of radio communication" provides an introduction to the principles of radio for those familiar with calculus. Since the entire scope of radio communication is covered in 400 pages or less, each topic is developed rapidly and it is impossible to provide an exhaustive treatment of any topic.

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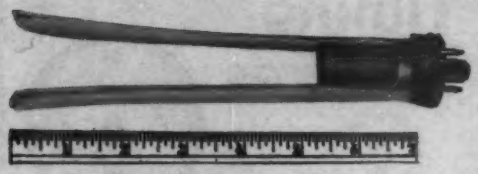

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take three job sheets; No. 23 is on the use of the wire gauge, No. 24 on coil winding, and No. 25 on building a crystal set. Two cover capacitance, one deals with a.c., No. 29 is Construction of an Audio Oscillator, and No. 30 is Action of a Rectifier Tube.

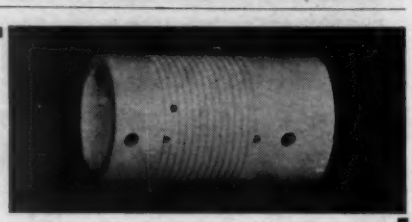
The book is highly recommended for use in radio shop classes.—J.M.

• • •

Table of the Bessel Functions $J_0(z)$ and $J_1(z)$

WPA MATHEMATICAL TABLES PROJECT, *conducted under Sponsorship of National Bureau of Standards. Published by Columbia University Press, Morningside Heights, New York 27, N. Y., 1943, 406 pages, $5.00.*

BESSEL FUNCTIONS of orders zero and one are encountered in the general solution of boundary value problems arising in the theory of potential, heat conduction, and wave motion, when the domain is bounded by a circle or a circular cylinder. In particular, they occur in the problem of propagation of electromagnetic waves with a



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tion of a quantitative concept of radio communication.

The volume can be recommended as an introductory volume for those who possess training in science or general engineering but are not familiar with the principles of radio.—B.D.

• • •

Principles of Powder Metallurgy

BY FRANZ SKAUPY, *Philosophical Library, Inc., 15 E. 40th St., New York; 1944, 80 pages, price $3.00.*

THIS TRANSLATION of what apparently was originally a German report on developments in powder metallurgy was written when the author first recognized the importance of the method in the manufacture of bearings, cutting tool tips, and machine parts. It is based on previous successful applications to electric lamp filaments, electrical contact points, anodes for x-ray tubes, magnet cores, and small crucibles.

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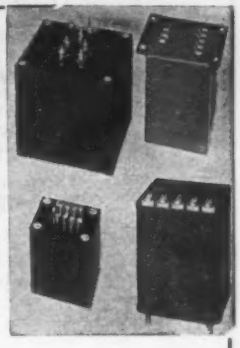

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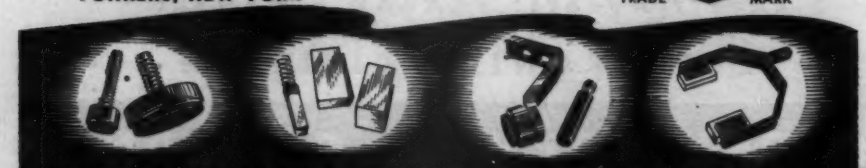

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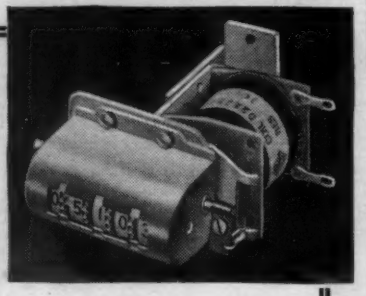

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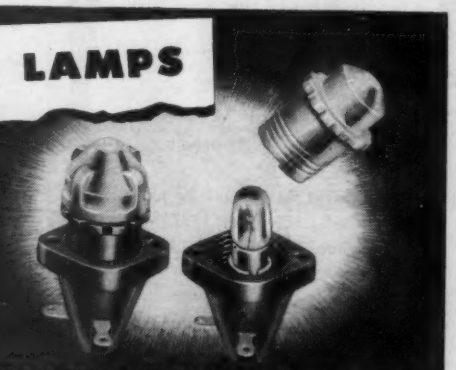

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cussion of spark transmitters. It seems unfortunate that this type of transmitter is not permitted to die its natural death. Throughout, emphasis is placed on fundamental principles rather than on commercial practice.

The physical interpretation of the operation of radio circuits is well done and only a moderate amount of mathematics is used. For the most part the mathematical derivations are rather concise and compact. On page 219 an error occurs in the expansion of $\sinh \beta t$ as $\beta t \rightarrow 0$. Although the expansion is incorrectly carried out, the final result, for the current in an RL circuit for critically damped conditions, is correctly given.

The volume is certainly more advanced than the practical texts on radio which aim to present only a qualitative descriptive picture of communications. But it is not sufficiently elaborate or exhaustive to be a text or reference for the communications engineer. As the author states, the main feature of this book is its compact presenta-

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laboratory research point of view, describing first the production of metal powders and their properties, then the production and properties of powdered metal or "ceramic metal" parts with and without binding agents. Particular attention is given to the metals tungsten, molybdenum, and tantalum and relatively little to bearing metals and powdered iron parts.

The discussion of methods is largely confined to laboratory technique and methods but contains details of manufacturing procedure that are not found in other books and technical publications. The language is often more scholastic in tone than that of an industrial metallurgist.—M.G.V.

• • •

20th Century Engineering

BY C. H. S. TUPHOLME, *Philosophical Library, 15 E. 40th St., New York, N. Y., 1944, 201-xi pages, price $3.*

ACHIEVEMENTS OF THE PAST decade in many branches of engineering are briefly explained in this book, with emphasis on British developments since the author is British and the book was written in England. The author's aim was to select and digest a number of interesting engineering developments for the benefit of engineers and members of the armed forces who wish to keep abreast of what has been happening. However, because it was written two or three years ago many of the most recent developments that one would look for are missing.

Chapters cover mechanical power, shop processes, air conditioning and refrigeration, chemical and metallurgical engineering, electric engineering, traction, marine engineering, aircraft and physics. Engineers who are interested in European developments in engines and power systems will find the opening chapter helpful. The section on shop processes is limited chiefly to oxy-acetylene cutting and hardening, chromium plating to extend life of tools and parts and to build up worn parts, precision machining and finishing, and methods of inspection and testing.

The chapter on chemical and metallurgical engineering covers plastics, a gas hyper-compressor for

(*Continued on page* 412)

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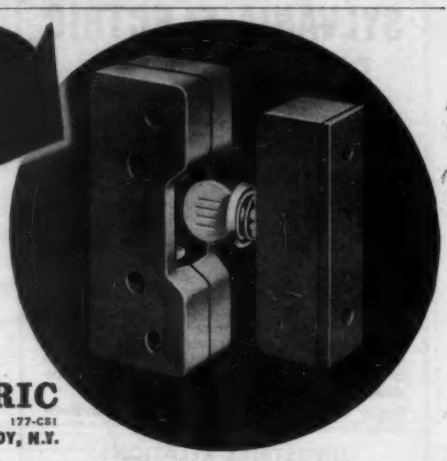

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Many types of military aircraft and their features and equipment are described in the aircraft chapter, but all of the models have now been superseded. No mention is made of the de Havilland Mosquito, a 110-percent British developed and manufactured plane. Only two pages are devoted to physics, covering the electron microscope, ultrahigh-speed X-ray photography and the chloral hydrate treatment for restoring burned documents. Radar is given two paragraphs at the end of the aircraft discussion.—K.S.P.

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How to Pass Radio License Examinations

By CHARLES E. DREW, *John Wiley & Sons, Inc., New York, Second Edition, 1944, 320 pages, price $3.00.*

A REVISED VERSION of the collection of answers to some 1300 questions in the FCC Study Guide. Discussion material has been added in small type after some answers to clarify reasons for answers. New material includes data on operation of circuits to provide maximum frequency stability in transmitters and extra data on modulation, oscillators, classes of amplifiers and rectifier power supplies. The six chapters of the book correspond to the six elements in FCC examinations: Basic radio laws; basic theory and practice; radiotelephone; advanced radiotelephone; radiotelegraphy; advanced radiotelegraphy. The new edition, like its predecessors, provides a valuable and efficient means of refreshing theorectical knowledge in preparation for the examinations.—J.M.